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27 *Abstract*

~~ABSTRACT.~~ The primary purpose of this project was to conduct an investigation to locate hidden or unknown drift mine openings in the Browns Creek Watershed in Harrison County, West Virginia. Thirty unknown openings were discovered in an initial reconnaissance. Additional probing using power driven augers was not successful and was deemed impractical. Three specific areas within the watershed were selected for further scrutiny. The bottom of the highwall line in the strip mined area was determined by land surveyors and this information was plotted on old mine maps to indicate the intersection of the stripping with underground mining. A minimum of 107 mine drifts were shown to be exposed by the 14,500 feet of highwall surveyed in the three areas. ~~This report was submitted in partial fulfillment of Contract No. 14-12-453 between the Federal Water Pollution Control Administration and the Halliburton Company.~~

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Abstractor

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INVESTIGATIVE MINE SURVEY
OF A SMALL WATERSHED

A Field Investigation to Locate and Define Unknown or
Hidden Drift Mine Openings in the Browns Creek Watershed
of the West Fork River in West Virginia

by

Halliburton Company
Duncan, Oklahoma 73553

for the

FEDERAL WATER QUALITY ADMINISTRATION

DEPARTMENT OF THE INTERIOR

Program Number 14010 DMO

FWPCA Contract No. 14-12-453

March, 1970

WATER POLLUTION CONTROL RESEARCH SERIES

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The primary purpose of this project was to conduct an investigation to locate hidden or unknown drift mine openings in the Browns Creek Watershed in Harrison County, West Virginia. Thirty unknown openings were discovered in an initial reconnaissance. Additional probing using power driven augers was not successful and was deemed impractical. Three specific areas within the watershed were selected for further scrutiny. The bottom of the highwall line in the strip mined area was determined by land surveyors and this information was plotted on old mine maps to indicate the intersection of the stripping with underground mining. A minimum of 107 mine drifts were shown to be exposed by the 14,500 feet of highwall surveyed in the three areas. This report was submitted in partial fulfillment of Contract No. 14-12-453 between the Federal Water Pollution Control Administration and the Halliburton Company.

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INTRODUCTION

Synopsis of Previous Study

A previous contract to the Halliburton Company consisted of a feasibility study in four parts on the application of various grouting agents, techniques and methods to the abatement of mine drainage pollution. This study, conducted from December 1966 to May 1968, included a survey of mine drainage pollution in the upper West Fork River Sub-basin near Clarksburg, West Virginia. This area is located on the map attached as Figure 1.

The Monongahela River is formed by the confluence of the West Fork and Tygart Valley Rivers, which occurs approximately five miles north of the northern boundary of Harrison County, near Fairmont, West Virginia. This study was concerned primarily with that portion of the West Fork River Basin which terminates immediately south of Clarksburg in Harrison County and extends to the headwaters in Upshur County. The Sub-basin contains approximately 400 square miles and more than 200 drift mines.

Clarksburg, the fifth largest city in the State and seat of Harrison County, is the major center of population and industry in the Upper West Fork River Sub-basin. Situated at the base of the Sub-basin, the city obtains its water supply directly from the West Fork River. Numerous other communities are interspersed throughout the Sub-basin and also take their water supplies from the river or its tributaries.

The feasibility study included an initial survey made by reconnaissance parties throughout the Upper West Fork River Sub-basin. All mined areas as revealed from information furnished by the Monongahela River Mine Drainage Remedial Project were included in the survey.

The reconnaissance party located and identified the openings which were evident within the Sub-basin and drainage water was noted, sampled and analyzed to determine the acid and mineral content. The geology of the mine sites was also recorded. A total of 228 drift mines or openings were discovered in this survey. A resurvey was then conducted on 60 mines which evidenced measurable flows during the preliminary survey, or had drainage with high mineral content.

Possible remedial techniques to abate the flow of mine drainage from the mines in this area were studied and a listing of the various methods was made. A drift mine which had an acidic drainage coming from the mine opening was selected for the installation of a mine seal. The seal installed consisted of four layers of cloth retainers which were allowed to conform to the shape of the mine floor, walls or roof as the material hardened. When complete, the stack of retainers formed a seal which conformed to the shape of the opening.

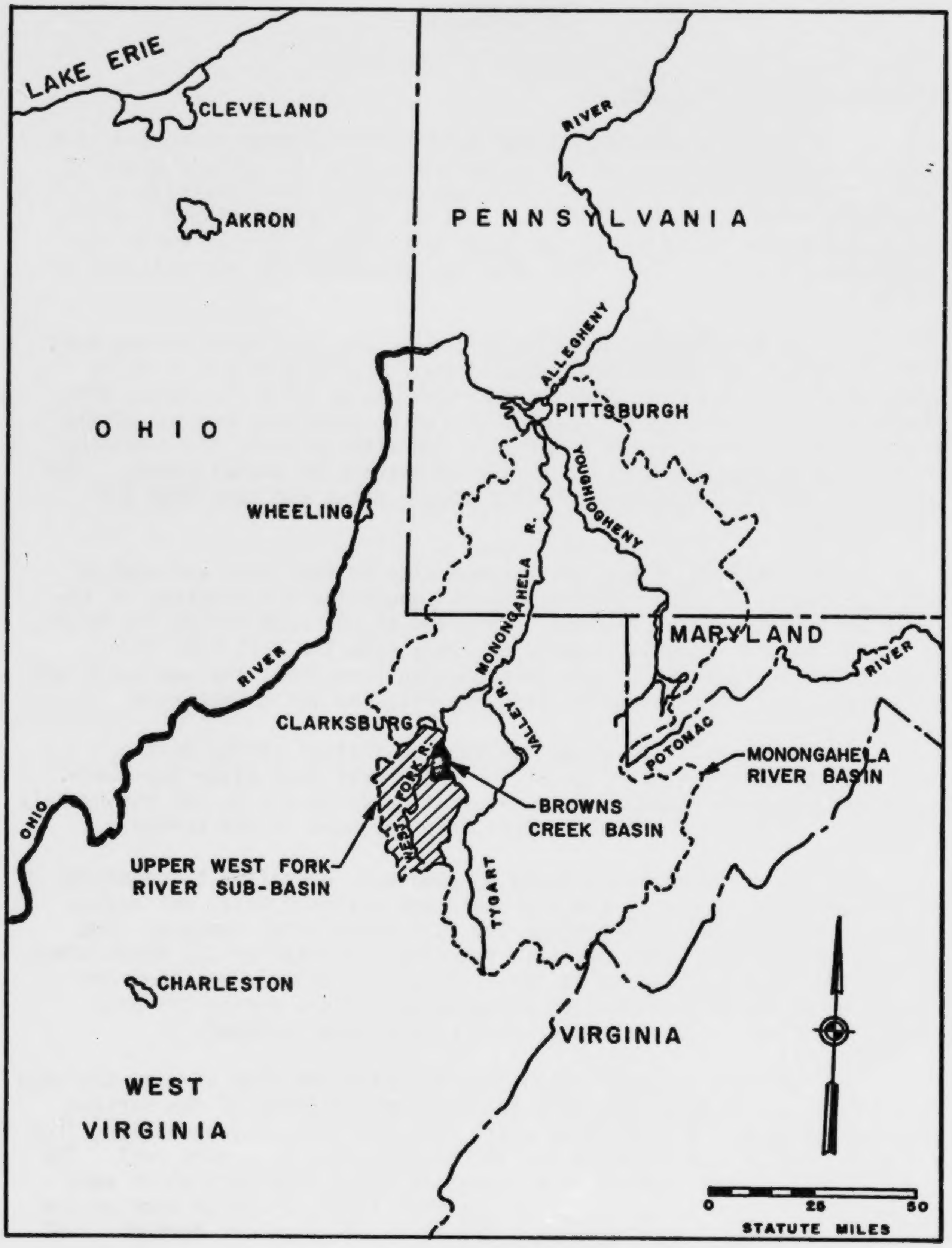

LAKE ERIE
CLEVELAND
AKRON
PENNSYLVANIA
RIVER
ALLEGHENY
PITTSBURGH
OHIO
YOUGHIOGHENY
WHEELING
MONONGAHELA R.
MARYLAND
RIVER
RIVER
VALLEY R.
CLARKSBURG
POTOMAC
MONONGAHELA RIVER BASIN
WEST FORK R.
BROWNS CREEK BASIN
OHIO
UPPER WEST FORK RIVER SUB-BASIN
TYGART
CHARLESTON
VIRGINIA
WEST VIRGINIA
0
25
50
STATUTE MILES

FIGURE I - GENERAL LOCATION MAP

Three other mine complexes were selected which were felt to be representative of the flow and acid drainage of those within the basin. Complete plans and specifications were drawn up for abatement construction work on the mine openings, utilizing the grout retainer seal technique as well as other sealing methods. Additional work in the study included research on the grout retainer technique of sealing a mine, with emphasis being given to development of a cement slurry which would permit the seal to be placed in one working day.

Scope and Purpose of Present Study

The program of work reported herein was undertaken to investigate a given drainage basin for location and delineation of any unknown or hidden drift mine openings. Research was also conducted to develop background data for improved knowledge of mine drainage.

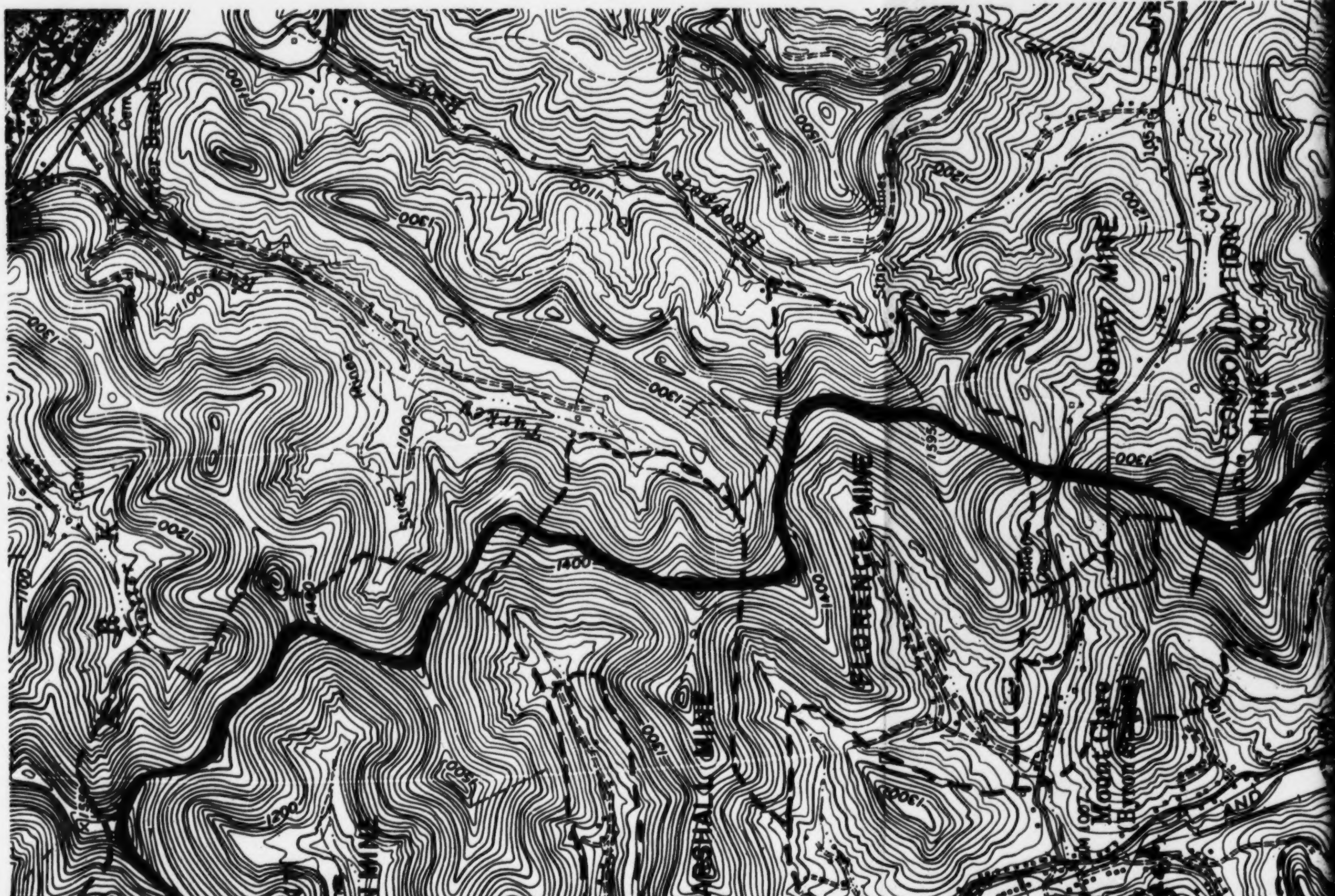
Based on the previous mine surveys conducted, the Browns Creek Area was selected as the drainage area in which an intensive investigation was conducted to locate mine openings to permit proper abatement method evaluation. The Browns Creek Area is located on the map attached as Figure 2.

The first phase of the work was a resurvey of the entire area by a reconnaissance party to confirm all visible and suspected openings. The openings definitely confirmed were noted on a map and the physical characteristics compiled. The party conducted probing and power driven auger borings in attempting to locate hidden openings.

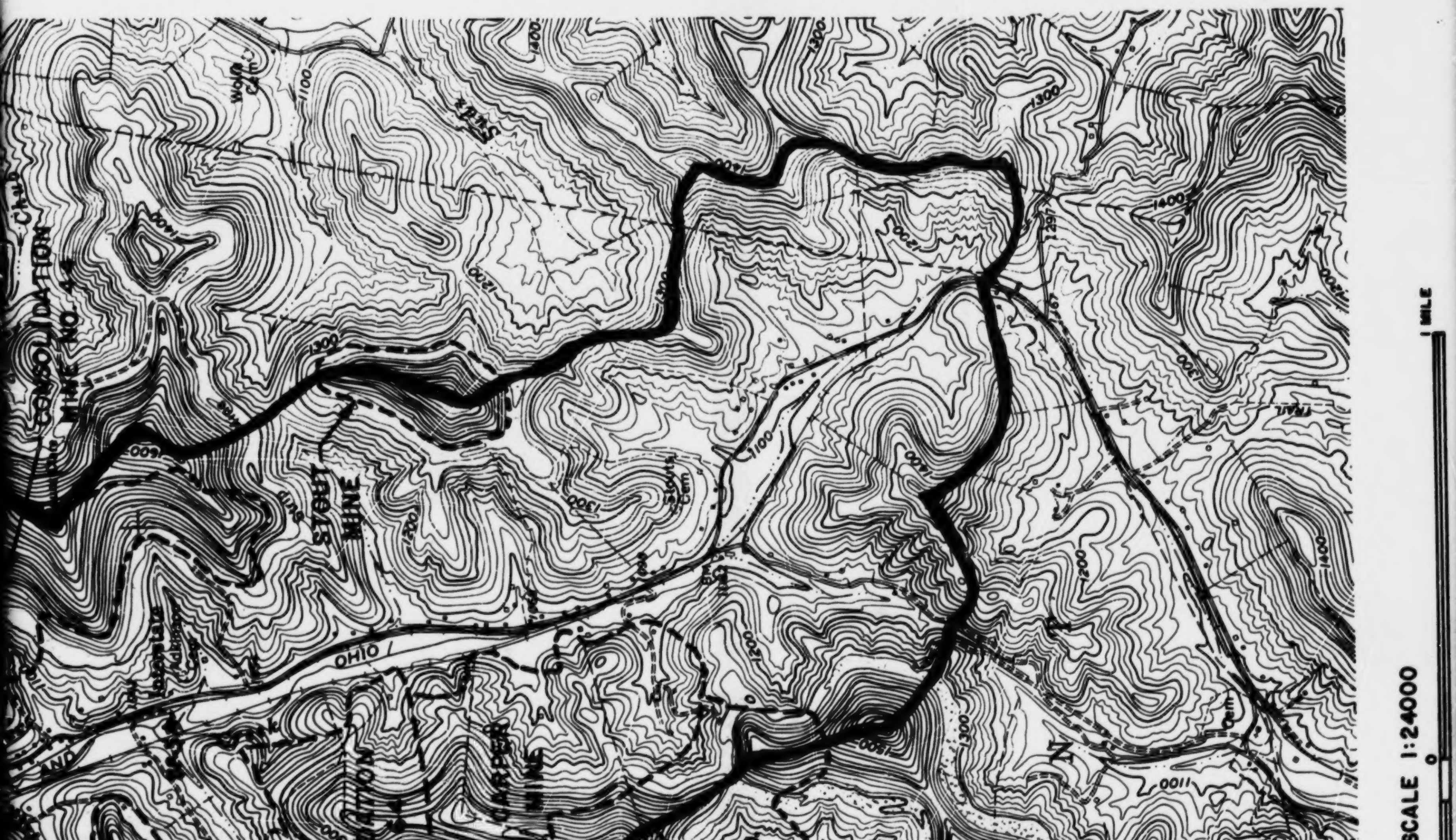
Using all the mine maps available from the Browns Creek area, a composite mine map of the Sub-basin coal field was constructed. Three separate mining complexes, for which the best mine maps were available, were selected for a detailed study. A land surveying party located the bottom of the highwall line in the three selected areas. This highwall line was then designated on the map of each individual area. This system would be used to aid in finding hidden openings.

The second phase of the work involved the comparison of water tables and water quality between mined and unmined areas. Wells and streams in both mined and unmined areas were monitored, sampled and analyzed to obtain the comparative data.

In conducting the reconnaissance, investigations, stream sampling and flow measurements in the Browns Creek coal field, no difficulty was experienced in gaining entry to the mine sites or to the surrounding properties. While many of the sites surveyed or visited were unoccupied, when property owners, caretakers, lessees or renters were encountered, they were both cooperative and interested. Access rights at Mine No. 40-058 were obtained in order to conduct probing and power driven auger borings.


BIG VEIN MINE
MARSHALL MINE
FLORENCE MINE
RONAY MINE
CONSOLIDATION MINE NO.
RIVER
1400
1300
1200
1100
1000

A


CONSOLIDATION
STOUT MINE
OHIO
CONSOLIDATION
CARPER MINE
COAL CO.
MINE
SCALE 1:24000
MILE
N

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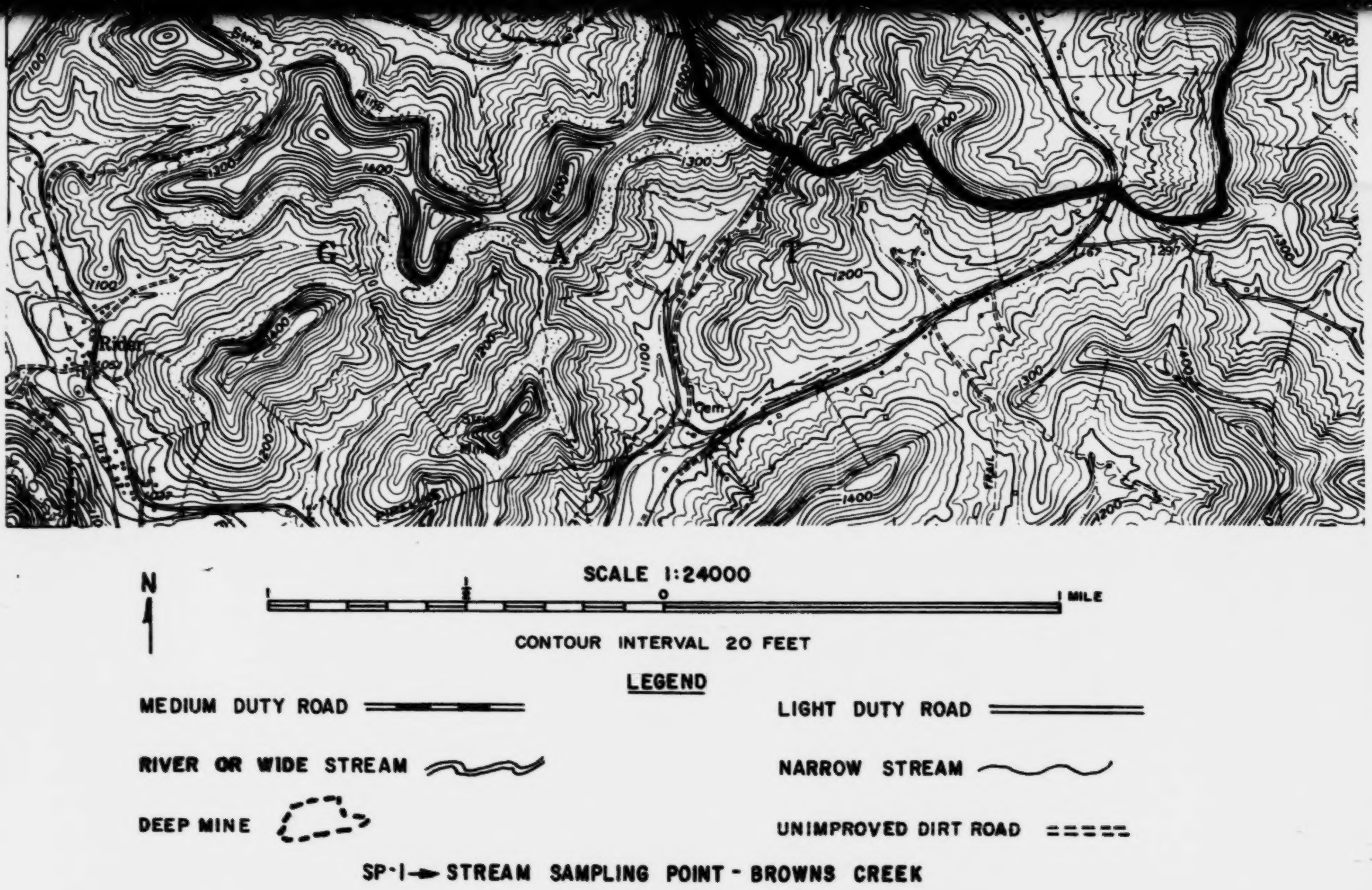
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1
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0
1 MILE
CONTOUR INTERVAL 20 FEET
LEGEND
MEDIUM DUTY ROAD
LIGHT DUTY ROAD
RIVER OR WIDE STREAM
NARROW STREAM
DEEP MINE
UNIMPROVED DIRT ROAD
SP-1 → STREAM SAMPLING POINT - BROWNS CREEK

FIGURE 2-MAP-BROWNS CREEK AREA

C

CONCLUSIONS

Numerous findings have resulted from the tests and evaluations performed under this contract. The following conclusions are drawn from these findings:

(1) Browns Creek is a major contributor to the pollution of the West Fork River at Clarksburg, West Virginia.

(2) The reconnaissance survey located 30 additional openings and defined their physical characteristics; however, this method can only locate those openings which are visible or are draining. As the reconnaissance survey would result in locating only a small part of the total hidden openings in a reclaimed strip mined area, it can be used only as a preliminary survey.

(3) Tests to locate hidden openings using a small power driven auger were not successful. It is concluded that this method is not practical except for above grade openings which would release mine drainage whenever an opening was penetrated.

(4) Land surveying to define the actual bottom of the highwall line and plotting the survey results on a mine map was the most thorough method employed to locate hidden openings. A limitation of this method is the need for reasonably accurate mine maps on which the survey results may be plotted.

(5) On the east side of the Browns Creek Watershed, a head of water as high as 150 feet could be accumulated behind a seal in the Pittsburgh coal seam of the Fairmont Big Vein Mine.

(6) The intersection of deep mine drifts by strip mining operations created a variety of opening configurations. The mine sealing techniques developed under this contract would undoubtedly be applicable to many of these openings, but it would be difficult to plan any specific abatement method which might be applicable to all the openings in the complex Browns Creek Area.

(7) After observing water levels in a well in both mined and unmined areas for 10 months, it was concluded that mining operations affect the water table levels but do not affect the water quality of water tables deeper than the mined coal seam.

(8) Although no difficulty was encountered in gaining entry to mine sites for the investigations conducted, obtaining access rights for field abatement applications can be very difficult and require a considerable expenditure of time and money. It is vital and necessary to obtain these agreements well in advance of any actual work.

RECOMMENDATIONS

Based on the conclusions drawn in this study, the following recommendations are submitted:

(1) It is recommended that the land survey method be utilized to determine probable conditions present in any area being considered for abatement construction work.

(2) It is recommended that the balance of the stripped area of the Browns Creek Watershed be surveyed using the land survey method to determine the probable number of openings exposed. A detailed engineering study should be performed to provide basic information needed for any abatement program which might be considered for the Browns Creek Watershed.

(3) It is recommended that a small controlled watershed, which does not have the complex problems of the Browns Creek area, be selected for further work. An engineering survey should then be made, followed by performance of abatement work using remedial techniques developed under this or other contracts. Mine No. 40-058, an isolated mine in the Browns Creek Watershed, might be a suitable area for this study, since mine sealing at this mine could potentially reduce the acid load of Browns Creek by 3,678 pounds per month and give valuable cost information for planning larger abatement programs.

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BROWNS CREEK INVESTIGATION

Browns Creek is a tributary to the West Fork River south of Clarksburg, West Virginia. The West Fork River, which rises south of the Ireland community in Lewis County, West Virginia, flows northward through Harrison County into Marion County, where it joins with the Tygart Valley River near Fairmont, West Virginia, to form the Monongahela River. That portion of the West Fork River Basin south of Clarksburg, West Virginia is considered the Upper West Fork River Sub-basin. It is approximately 65 miles in length and contains an area of 384 square miles to that point.

Browns Creek has its headwaters in the hilly terrain about two miles south and east of Mount Clare, Harrison County, West Virginia, a community of about 1,000 population. The watershed, approximately 6.8 square miles in area, is located 2.5 miles upstream (south) from Clarksburg, West Virginia.

Browns Creek flows in a north-northwesterly direction along the longitudinal axis of the watershed for a distance of about 4.5 miles and empties directly into the West Fork River. It is fed by intermittently flowing tributary streams which range in length from 2,000 to 5,000 feet. These streams carry surface runoff from the watershed as well as some ground water, including drainage from abandoned coal mines located at higher elevations. Figure 2 shows a map of the Browns Creek area.

The topography of the watershed is rugged. Elevations range from 940 feet above sea level at the mouth of Browns Creek to 1,450 feet near its source. Browns Creek flows on an average gradient of 50 feet per mile through a deep valley, while the principal tributaries have average gradients of approximately 150 feet per mile. These smaller flowing or intermittently flowing streams drain the numerous valleys in the watershed. A number of these streams carry mine drainage from coal seams located at higher elevations.

Alluvial deposits in the channels and on the flood plain of Browns Creek are responsible for the flat area in the drainage basin. These areas are generally narrow and traversed by State Highway 25, County highways and the Baltimore & Ohio Railroad, which was extended into the valley before the turn of the century. The town of Mount Clare and small residential clusters are also located in the valley. Where light industry and residential areas do not exist, these relatively level areas contain only minor amounts of woodland and are used principally for grazing and gardening.

The slopes of the very hilly terrain are generally wooded, although some slopes are used for grazing. The area, once heavily timbered, has been cut over several times. Extensive drift and strip mining of the Pittsburgh coal seam has been accomplished where no further strip mining operations are contemplated, approximately two-thirds of the stripped area has been reclaimed by regrading mine spoil and original overburden over the stripped area so as to create a "bench" on the face of the hillside slope. Many of these benches have been reclaimed to grazing land or have been reforested; however, the near vertical highwall resulting from "benching" the original hillside slope for the stripping operation is exposed and is weathering to the extent that sloughing of the existing overburden over the highwall as well as the highwall itself is in evidence. In some cases the Pittsburgh coal seam has been completely strip mined circumferentially around hillsides so that the remaining hilltops appear as knobs.

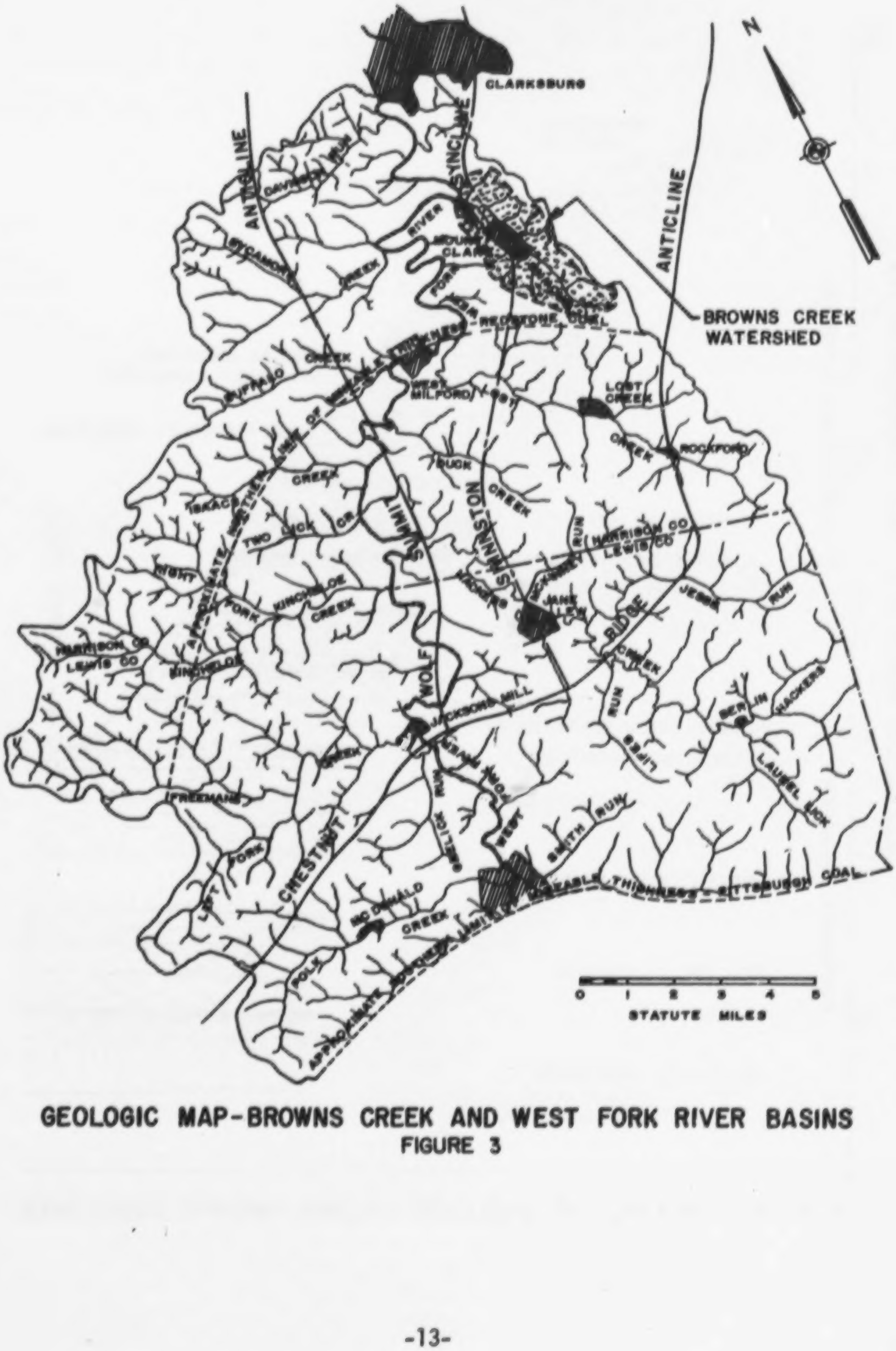
A geologic map of part of the West Fork River Sub-basin containing the Browns Creek watershed is attached as Figure 3. Two anticlines, Chestnut Ridge to the east and Wolf Summit to the west, dominate the watershed. A secondary or minor geologic structure, the Shinnston Syncline, actually defines the Browns Creek area. The entire drainage system in the area is strongly influenced by these geologic structures. The Shinnston Syncline, running in a northeasterly, then northerly, direction and dipping downward, passes through the Browns Creek watershed and aligns itself with Browns Creek for approximately 1.5 miles to its confluence with the West Fork River. Because of the immediate location of this Syncline with respect to Browns Creek, strata dip toward the creek and essentially in the same directions as the natural surface drainage.

The general stratigraphy of this area is not complex and can be readily observed in the field. The series of strata ranges from the Monongahela to the Conemaugh, the former overlying the latter, in the order of stratigraphic sequence of the Pennsylvanian Period. A generalized geologic column is included as Figure 4. Also the natural outcropping on hillsides, as well as the numerous exposures at mine sites, abundantly reveal marked similarity in lithological character throughout the area.

The geologic literature indicates that this area has gone through at least two complete periods of erosion and re-elevation. The watershed is known to have eroded to a peneplain sometime during Cretaceous time and re-elevated and re-eroded in the Tertiary Period. At the closing of the Tertiary, the land was re-elevated once again and at the present time is being eroded. However, the field study shows that uneven erosion has taken place not only in the layers of the Monongahela Series, which exist in the northern section of the study area, but by the absence of this Series in the southern section. It is obvious that these totally missing strata are the result of a higher degree of uplift in the southern region which has provided a far greater potential for subsequent erosional forces.

A second effect of this increased uplift activity is the exposures in the southern portion of the study area of older rocks above the natural drainage. This is evidenced by the outcrops of the older Conemaugh Series which are not in evidence in the north.

Although the Cedarville sandstone appeared to be the highest and therefore the youngest stratum of the Monongahela Series at the


N
CLARKSBURG
ANTICLINE
SYNCLINE
ANTICLINE
BROWNS CREEK
WATERSHED
DAVISSON RUN
SYCAMORE
CREEK
RIVER
MOUNT
CLARE
FORK
REDSTONE COAL
BUFFALO
CREEK
WEST
MILFORD
LOST
LOST
CREEK
CREEK
ROCKFORD
DUCK
CREEK
CREEK
ISAACS
TWO LICK CR.
SUMMIT
STONE
HARRISON CO
LEWIS CO
RIGHT
FORK
KINCHELOE
CREEK
APPROXIMATE
HARRISON CO
LEWIS CO
KINCHELOE
JANE
LEW
RIDGE
JESSE
RUN
CREEK
RUN
LIFES
BERLIN
HACKERS
LAUREL
LICK
WOLF
JACKSONS MILL
CREEK
RUN
FREEMANS
CHESTNUT
LEFT
FORK
GOOSELICK
WEST
SMITH RUN
PITTSBURGH COAL
MC DONALD
CREEK
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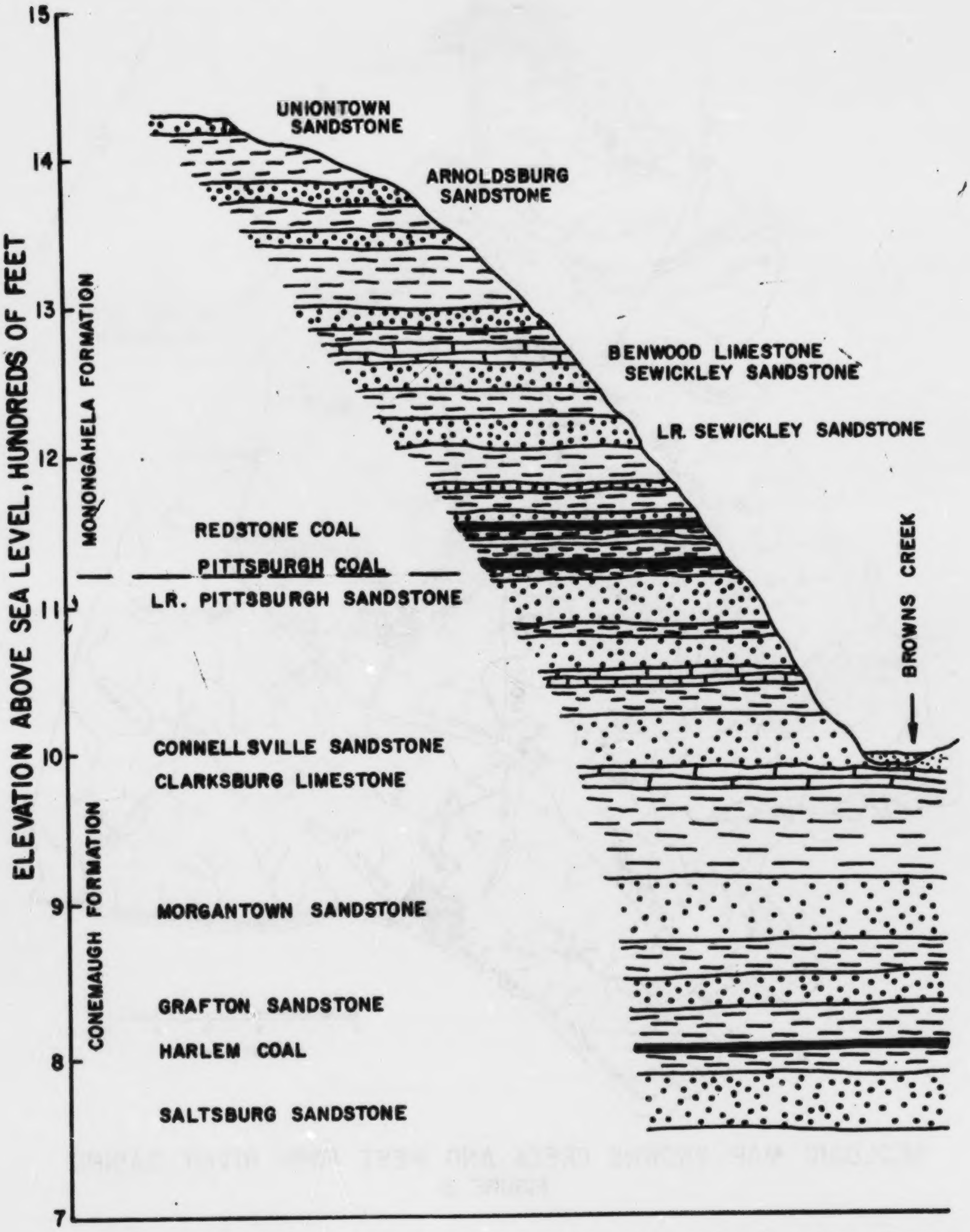
GEOLOGIC MAP-BROWNS CREEK AND WEST FORK RIVER BASINS
FIGURE 3


15
14
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7
ELEVATION ABOVE SEA LEVEL, HUNDREDS OF FEET
MONONGAHELA FORMATION
CONEMAUGH FORMATION
UNIONTOWN SANDSTONE
ARNOLDSBURG SANDSTONE
BENWOOD LIMESTONE
SEWICKLEY SANDSTONE
LR. SEWICKLEY SANDSTONE
REDSTONE COAL
PITTSBURGH COAL
LR. PITTSBURGH SANDSTONE
CONNELLSVILLE SANDSTONE
CLARKSBURG LIMESTONE
MORGANTOWN SANDSTONE
GRAFTON SANDSTONE
HARLEM COAL
SALTSBURG SANDSTONE
BROWNS CREEK

FIGURE 4 - GENERALIZED GEOLOGIC COLUMN - BROWNS CREEK AREA

highwalls and areas above the highwalls at mine sites surveyed, subsequent information indicates younger strata of the Monongahela Series to be present in higher peaks.

The Browns Creek watershed comprises a relatively large surface drainage area which is generally dendritic in pattern. This system has emerged as a result of erosion of a geologic plateau comprised of basically undisturbed sediments. The topography is generally low and rounded. Underground drainage in the watershed is largely governed by a series of broad geologic structures which enter into and extend through the watershed, causing considerable local variation in the subsurface drainage systems. In certain instances, the surface system corresponds to the subsurface system creating a condition whereby ground water draining from drift mine operations above the streams is collected and discharged to Browns Creek.

The average rainfall for the Browns Creek watershed is 42 to 44 inches per year. The Clarksburg precipitation recording station showed an average rainfall of 41.78 inches per year, based on 38 years of records.

Data obtained from the Weather Bureau State Climatologist at Morgantown, West Virginia indicated that the average annual evapotranspiration for the Browns Creek watershed is slightly over 28 inches. The average rate for the five months of May through September is approximately 23 inches, which is about equal to the rainfall received during the period. This would indicate low stream flows for that period of the year and much higher runoff during the other seven months.

Ground water in the watershed is derived chiefly from the infiltration of rainfall and snow melt which has percolated to and is stored in the voids of underlying shales and sandstones. When these voids become saturated, the ground water moves slowly to areas of discharge, which are usually lowland areas that are characterized by springs, seeps and streams. Ground-water levels are at their highest in late winter or early spring and at lowest in late summer or early fall.

The area of the watershed has been mined using drift, strip and auger mining methods. The Pittsburgh coal bed, because of its commercial quality and thickness of 5 to 9 feet, has been extensively mined. The Redstone coal is not generally present in this area in commercially minable thickness. However, it is sometimes found in seams as thick as 2 feet. Where it exists, it has been stripped along with the Pittsburgh coal. Strip mining and augering have intersected underground mines and have exposed additional mine voids and provided new openings for air circulation, water entry and drainage which make a definite contribution to the pollution problem in this area.

Drift mining by hand began in the Browns Creek coal field in 1904. At the height of the mining activity, as many as eleven mines were in operation at one time. Mining drifts were usually terminated near the perimeter of the hill where the outcrop coal of poor quality was encountered. This normally left 12 feet of cover above the coal seam, which was the minimum amount of overburden desirable.

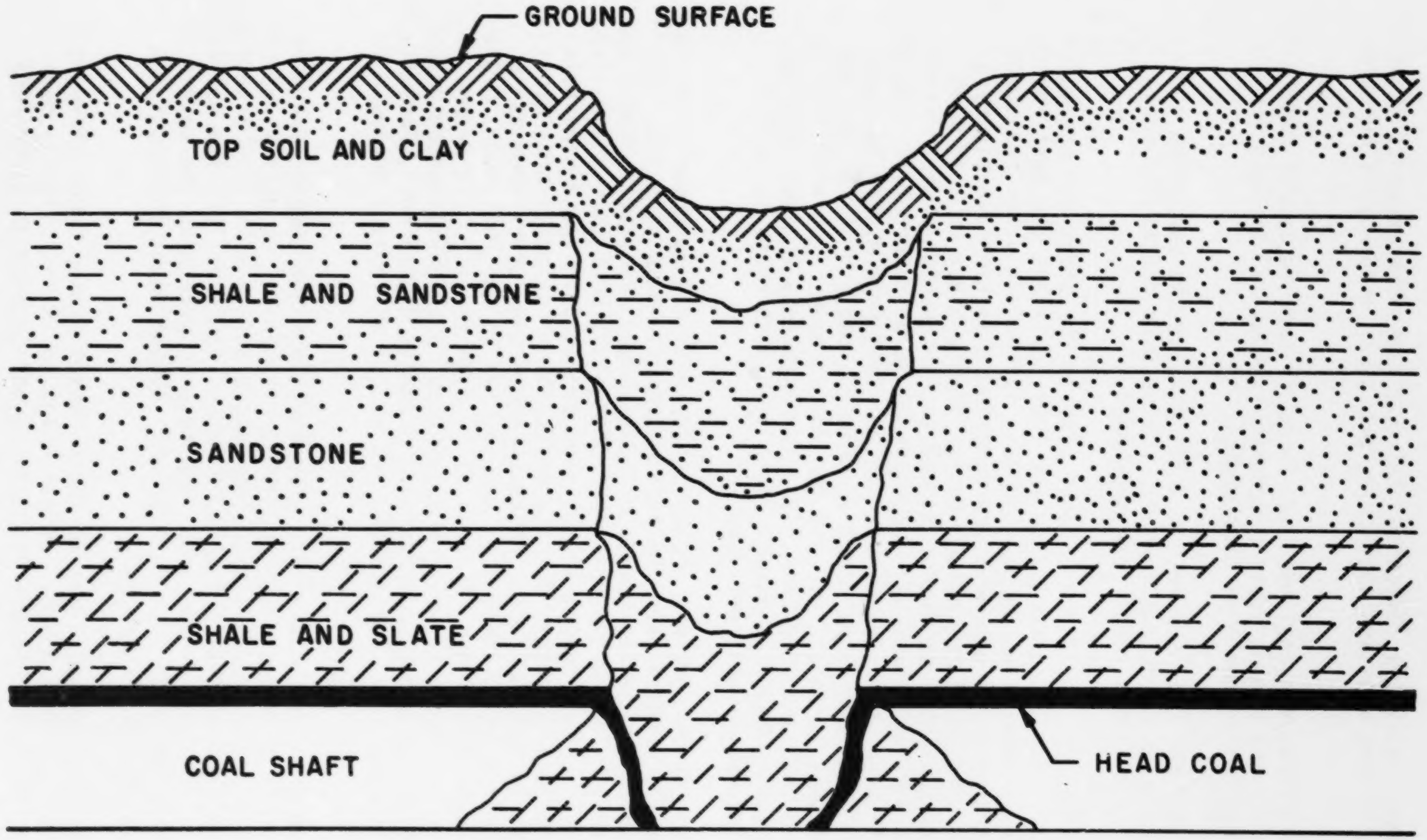
Most of the deep mines closed during the depression of the 1930's, although a few continued production through the 1940 decade. Prior to 1940, most of the mining in Harrison County was confined to the area north of Clarksburg, downstream from the city water supply source and, therefore, mine drainage did not appreciably affect the city water supply except for Browns Creek, where mining was active at the time.

After many of the drift mines had been abandoned, coal owners recovered the outcrop coal by stripping the perimeters of the old drift mines. In many cases, Pittsburgh coal was recovered after the stripping operations by augering with large diameter augers. The lateral extent of the holes was as much as 200 feet where no mine void was encountered. These abandoned auger voids serve as natural entry points for air and water contact at coal faces or as direct drainage channels.

During and following World War II, mining was very active in the southern portions of Harrison County and, to a lesser extent, in Lewis County. Primary mining methods were used to remove approximately 30 to 35% of the minable coal and secondary methods used to recover an additional 50 to 55%. Both mining methods were used in removing the coal from the commercial mines of the area. Small reserves of Pittsburgh coal remain in the Browns Creek coal field, but geological and economic conditions prevent much active mining at this time.

The secondary mining method, often referred to as "pillar removal", created large void spaces and left little support for the overburden load. Roof falls are prevalent throughout the abandoned workings of the area. These frequently create surface subsidence. These areas are normally identified by rounded depressions on the surface above mined-out areas. A drawing depicting this condition is attached as Figure 5. In most instances this occurs where the overburden is less than 30 feet. Should the overburden exceed 30 feet, it normally has sufficient inherent strength to remain stable. Subsidence also is associated to a great extent with the 12-foot cover line. These areas offer entrance points for surface and subsurface water runoff into the mined-out areas. Many of the mine drifts are partially or completely filled with debris.

Strip mining and augering were prevalent during and immediately following World War II. The stripped areas have usually been backfilled against the highwall. This procedure and sloughing of the highwalls made it very difficult to ascertain what additional openings were uncovered by the stripping operation, but seepage of water through the


GROUND SURFACE
TOP SOIL AND CLAY
SHALE AND SANDSTONE
SANDSTONE
SHALE AND SLATE
COAL SHAFT
HEAD COAL

TYPICAL SUBSIDENCE OF ABANDONED COAL MINE

FIGURE 5

backfill in many locations indicated that openings were present. Most of the mine maps of the area are available, but their accuracy is questionable.

The Pittsburgh coal has been found to contain approximately 4% total sulphur in the Browns Creek Watershed as compared to much less in the coal fields to the north of Clarksburg.

Brands Run Coal Company, a drift mine on the west side of Browns Creek near its headwaters, was the only active mine during the period of the contract, but it has since been abandoned.

Clarksburg, the fifth largest city in the State and the major center of population and industry in the area, utilizes the West Fork River for its potable water supply source. Increasing water treatment costs for treating total hardness and removing objectionable minerals have occurred because of the contamination of the river by acid mine drainage upstream. This pollution is caused by the highly mineralized mine drainage entering the river from several large tributaries. Browns Creek, one of these major tributaries to the West Fork River, has been cited by the Clarksburg Water Board as being so badly polluted for the past 40 years that it cannot be used for any purpose. The acid load being discharged into the West Fork River approximately 2 miles upstream from the Clarksburg Water Treatment Plant by Browns Creek is approximately 1,350 pounds of acid per day.

Some survey work was accomplished in this area under a previous contract with the Federal Water Pollution Control Administration. The information which formed the basis for this survey was that gathered during a 1965 study by the U.S. Department of Health, Education and Welfare. The mine classification system established and used in the Monongahela Enforcement Project inventory for identification and location of mines was maintained in this project. Mines in the Browns Creek area use a mine number prefix of 40 since they are located on the USGS Mount Clare (7.5-minute) quadrangle map. A total of 30 mine sites in the Browns Creek drainage area were surveyed and reported in the Halliburton report entitled, "Selection and Recommendation of Twenty Mine Sites", Part II, 1967, Appendix, Table B. These mines are listed in Table 1 included in the Appendix.

Five sampling points were selected along the length of Browns Creek in order to provide sufficient monitoring points to gather data on the stream flow and water quality. The sample points were established at strategic locations so that the data collected would reflect the pollution load distribution along Browns Creek and help to determine the source of the major contributors of acid mine water. Sample point locations are shown on the area map, Figure 2.

Sample Point No. 1 was at the mouth of Browns Creek where it flows into the West Fork River. Sample Point No. 2 was slightly over one-half mile upstream. Sample Point No. 3 was located at Alpha Penn

Road in Mount Clare. Sample Point No. 4 was opposite Mount Clare Lions Club Park. Sample Point No. 5 was across the road from the Interstate Building.

These points were monitored throughout the contract. Flow data for Browns Creek is included in the tables containing the analyses of samples. Flow reached a high of 3,774 gallons per minute during the monitoring period with an average flow at the mouth of 1,400 gallons per minute. Water analyses for samples taken at the five sample points are included as Tables No. 2, 3, 4, 5 and 6 of the Appendix.

The average acid load per day for the West Fork River at Clarksburg, West Virginia was 5,340 pounds in 1967. An average daily acid load of 1,339 pounds, or about 25% of the river load, was deposited by Browns Creek into the West Fork River. The average daily iron and sulfate load contributed by Browns Creek into the West Fork River constituted 81% and 23% respectively. The average load data for the West Fork River was obtained from the Federal Water Pollution Control Administration, Upper Ohio Basin Office, Wheeling, West Virginia. The load data for Browns Creek was calculated using the following formula:

$$\text{Load, pounds/day} = \text{Avg Flow (cfs)} \times \text{Avg Acidity (mg/l)} \times 5.4$$

Iron and sulfate loads were calculated with the same formula, substituting the average iron and sulfate values for the acid.

The pollution data for Browns Creek is shown in Table 7, attached in the Appendix. This table gives the acid, iron and sulfate loads per month for six segments of Browns Creek. This data indicates that the largest portion of the acid and iron load comes from the mines in the main Mount Clare area, and the largest amount of sulfate is produced by the Two Lick Hollow area. However, the acid loads from the other areas downstream from Sample Point No. 5 are almost equal to that from the main Mount Clare area. The iron and sulfate loads from the main Mount Clare area, the Two Lick Hollow area and the Hutchison Hollow comprise the main part of the pollution load, but each of the areas between the sampling points makes a significant contribution.

As the initial step in the location and identification of unknown or hidden openings created by mining in the Browns Creek area, a reconnaissance party conducted a thorough investigation of the area.

The survey was started at the south end of the area, east of State Route No. 25, and proceeded in a northerly direction along the east side of the area to the northern limits. It then proceeded south down the west side of Browns Creek to the headwaters. The area was covered on foot with all physical characteristics being noted, such as subsidence, existing openings that were still visible, evidence of mine workings by abandoned tipples, rails, etc. Further information was obtained from local residents in each of the areas who were knowledgeable on the location of deep, abandoned mines. Many mine openings had been covered by backfilling of stripping operations, subsequent slides and sloughing of the highwall. In most cases, the party was able to locate the main original mine headings, such as haulageways, main portals and fanways. Less significant openings, such as drainways, air vents, etc., are often difficult or impossible to locate and many are not shown on old existing mine maps.

A total of 51 mine openings were located by a previous survey conducted under the direction of the Monongahela River Mine Drainage Remedial Project. These openings are marked on the map attached as Figure 6. In addition, mines are outlined and numbered. Subsidence areas and gob piles are designated.

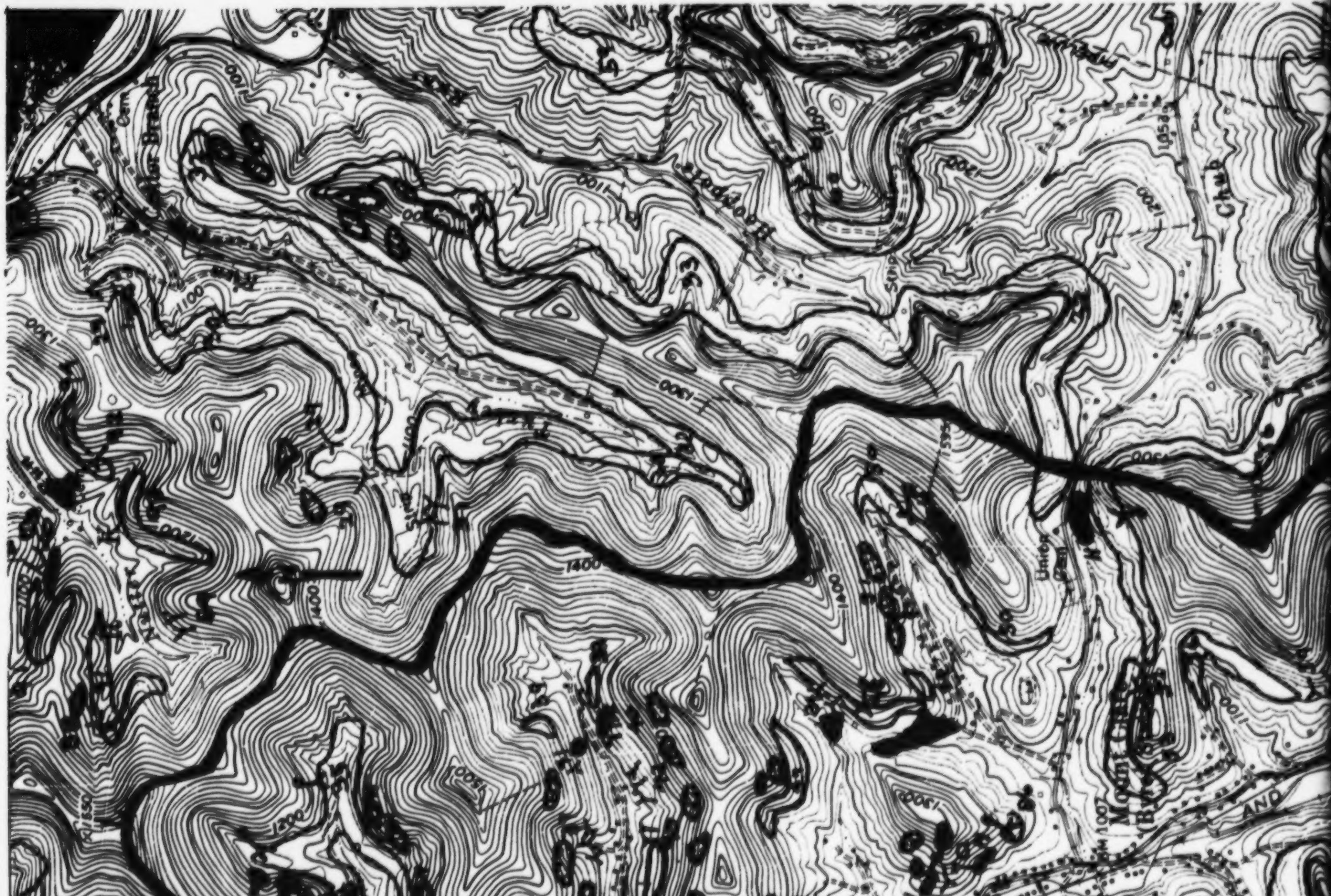
During the reconnaissance survey, 30 additional openings were located. These are designated on Figure 6 using a different symbol from the openings previously marked. Further areas of subsidence and gob pile locations were also determined and shown on the map. Physical characteristics of the 30 openings were tabulated and are listed in Tables 8, 9, and 10. Some of the openings found were monitored and sampled. Flow data and water analyses for the openings are given in Table 11. Many of the samples showed to have a pH value in the range of 3, with high acid and sulfate content. Some samples also showed high iron content.

Following the initial survey made by the reconnaissance party on foot, the site of the Stout Mine (Mine No. 40-058) was selected to test the use of a small, portable power-driven auger as a possible method of probing to locate hidden mine openings from the surface. Some openings were shown on existing mine maps, but have been covered by backfilling after stripping was completed. Other openings have actually been created in the stripping operation as the equipment cut into a drift or exposed a crosscut in the drift mine, and were then covered by backfilling.

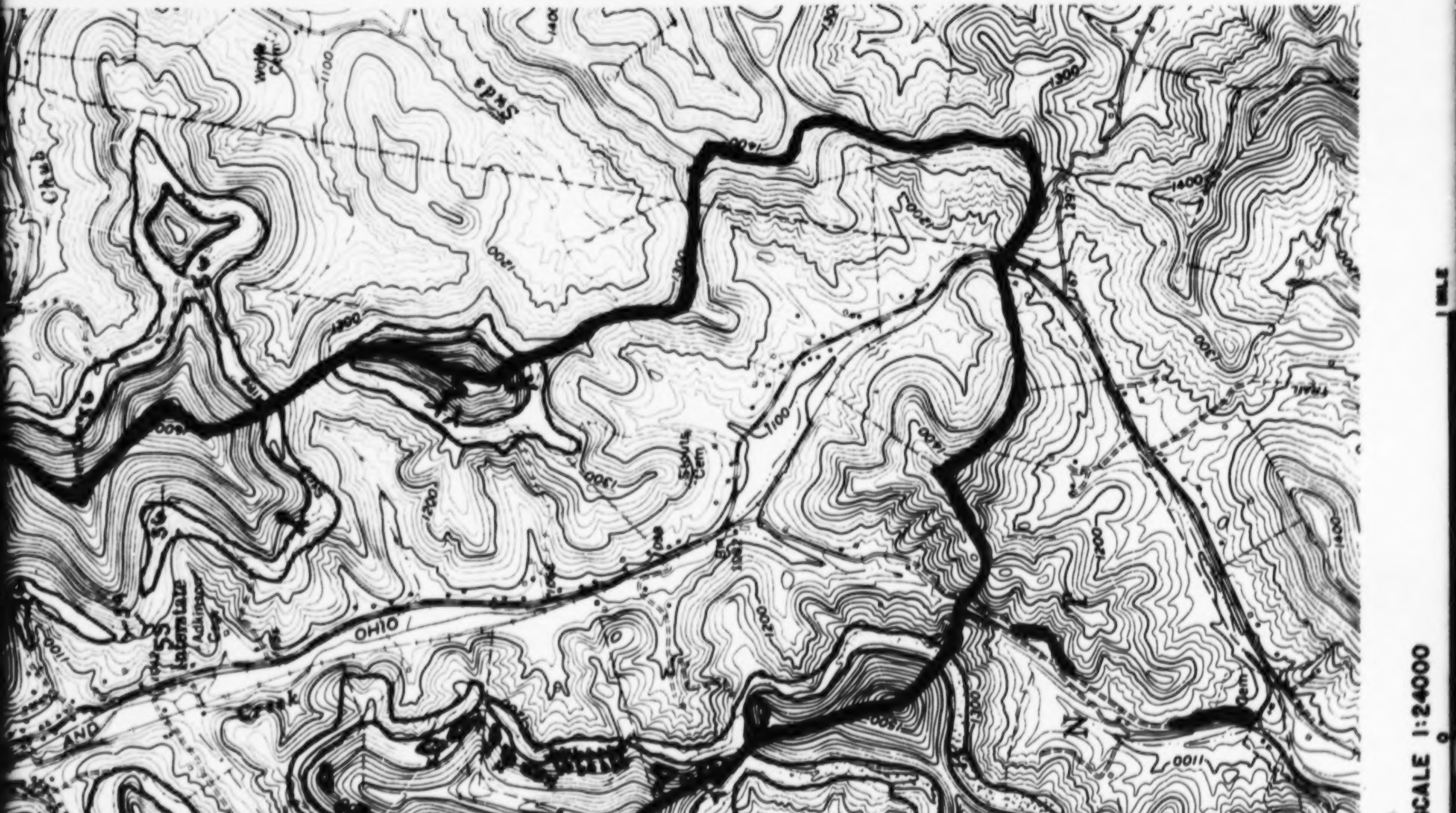
The augering machine had been developed for horizontal drilling of earth. It consisted of an engine driven auger flight with cutting head attached. The engine and auger flights were mounted on a movable frame, which permitted lateral movement of the cutting head.

The machine was set up on the bench in front of the highwall at Mine No. 40-058, using a downward elevation of approximately 12 degrees from horizontal. Subsidence was evident, but no openings were visible.

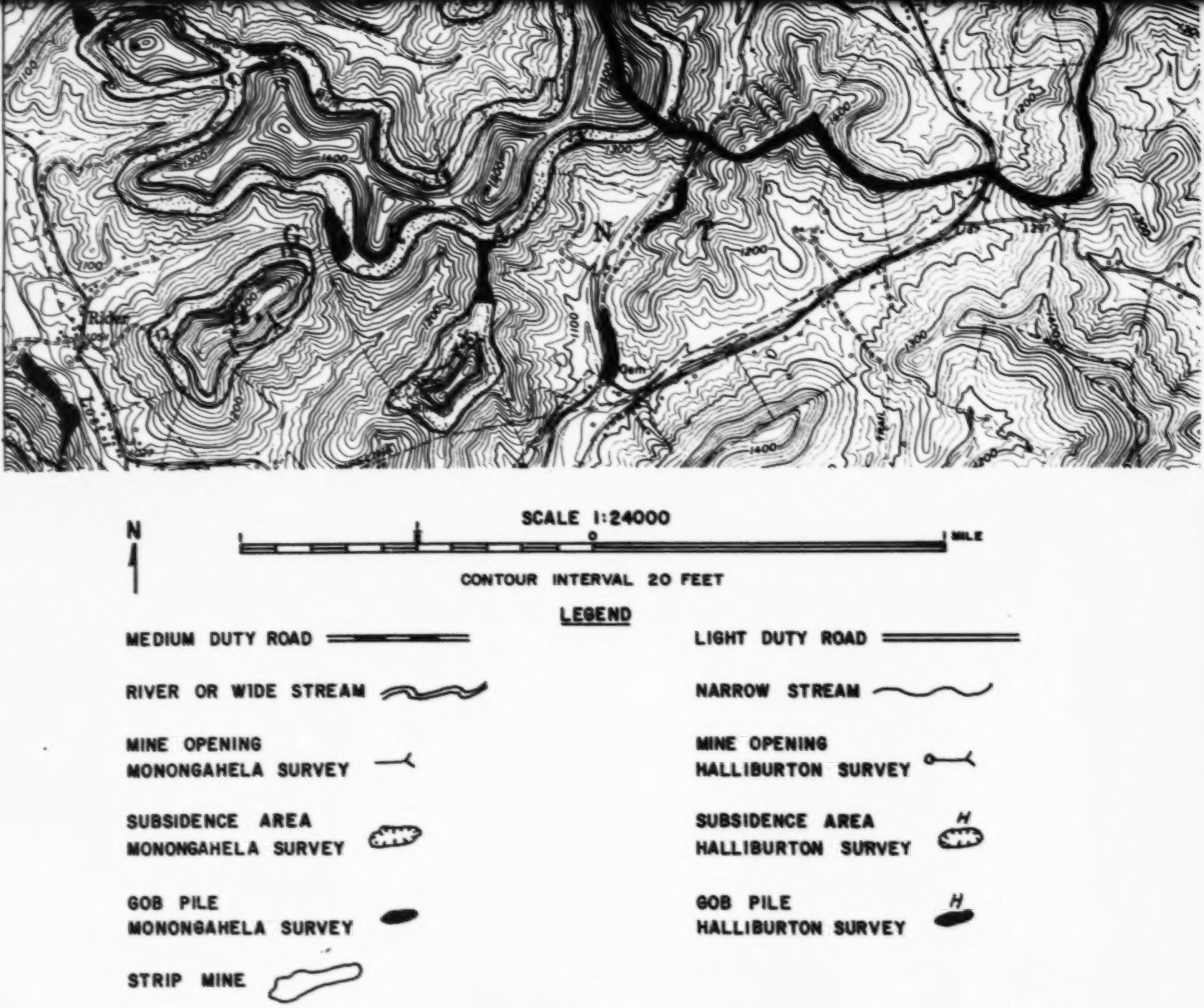
Drilling was begun and continued until stopped by a hard obstacle after 31 feet had been drilled. No cuttings could be obtained from this test, so it was very inconclusive. Four additional tests were made with similar results.


1400
1200
1300
1000
1100
RIVER
FORK
West
Brown
MINE
Chub
Union
AND
Clarksburg Country Club

A


SCALE 1:24000
0
N
Interstate
OHIO
AND
Creek
Chub
1100
1200
1300
1400
1500

B


1100
1200
1300
1400
Rider
N
SCALE 1:24000
1
½
0
1 MILE
CONTOUR INTERVAL 20 FEET
LEGEND
MEDIUM DUTY ROAD
LIGHT DUTY ROAD
RIVER OR WIDE STREAM
NARROW STREAM
MINE OPENING
MONONGAHELA SURVEY
MINE OPENING
HALLIBURTON SURVEY
SUBSIDENCE AREA
MONONGAHELA SURVEY
SUBSIDENCE AREA
HALLIBURTON SURVEY
H
GOB PILE
MONONGAHELA SURVEY
GOB PILE
HALLIBURTON SURVEY
H
STRIP MINE

MINE SURVEY MAP- BROWNS CREEK AREA

FIGURE 6

C

These tests were not successful because obstacles prevented drilling the hole to the anticipated depth to reach the coal seam, and it was difficult to identify voids encountered below grade.

A composite mine map of the watershed was constructed using all available mine maps of the Browns Creek area. Even though many of these maps were of poor quality, they are considered to be of better than average quality for the age of the mines. Figure 7 shows the mines located on the east side of Browns Creek. Figure 8 shows the mines on the west side of Browns Creek. Included on the maps are the drainage divides and the coal contours for each area. It can be noted that the coal contours on the east side of Browns Creek dip 150 feet from the area east of Mount Clare to the mouth of Browns Creek.

After obtaining the composite mine maps, a decision was made to select three areas within the Browns Creek watershed which might portray typical conditions of the watershed. These areas were then to be surveyed by a land surveying party to determine the bottom of the highwall line in the stripped area. The results of the survey plotted on a mine map would denote the openings which had been exposed in the stripping operation.

Examination of the composite maps disclosed that there were three areas which seemed to be well suited for this purpose. The first area chosen was Two Lick Hollow, near the mouth of Browns Creek where it empties into the West Fork River. This area, on the east side of Browns Creek, contains the Fairmont Big Vein Mine complex (Mine No. 40-035). The second area selected for survey was Hutchison Hollow on the west side of Browns Creek. This area contains the Byron Mine complex (Mine No. 40-066). The third area selected for survey was the Stout Mine (Mine No. 40-058), which is an isolated mine located near the headwaters of Browns Creek. It is located high above the rest of the area, since this is at the upper end of the coal in the Browns Creek mining area. These three areas, denoted on the composite maps, were selected because it was felt that they were typical of the Browns Creek area in general, and old mine maps were available for each of these. These areas were surveyed by a land surveying party to locate the bottom of the highwall line. The highwalls and the stripped areas were marked on the two composite maps.

The results of the detailed survey made in Two Lick Hollow are indicated on the large-scale mine map of the Fairmont Big Vein attached as Figure 9. This map is one of the better mine maps of the Browns Creek coal field. The present highwall line is denoted as well as the area which had been stripped from the mine. It can be noted on the map, by the intersection of the present highwall and mine drifts, that a large number of openings were uncovered by the stripping operation. A minimum of 40 drift openings were counted. Several sections from which pillars had been removed were uncovered, one of which was approximately 300 feet in length. There were

5,545 lineal feet of highwall measured in this survey.

Figure 10 shows a void created in the area of the Redstone limestone above the backfill. This void is designated as point "A" on the mine map (Figure 9) and is located at the east end of the right-hand strip area of the Fairmont Big Vein Mine. It appears from examination of the mine map that this void is due to the subsidence of the formations above the coal where the stripping cut into the No. 2 North heading. The base of the Pittsburgh coal would be about 20 feet below this void.

Figure 11 is another void in the area above the reclamation backfill located at the north end of the left-hand strip area. This void is designated as point "B" on Figure 9 mine map. It appears to have been created by subsidence of the formations above the Pittsburgh coal seam where the stripping cut into the No. 3 Left heading of the No. 2 North heading. A thin seam of Redstone coal is visible between the Redstone limestone and the shale and slate. The geologic section for this area is attached in the Appendix as Figure 28.

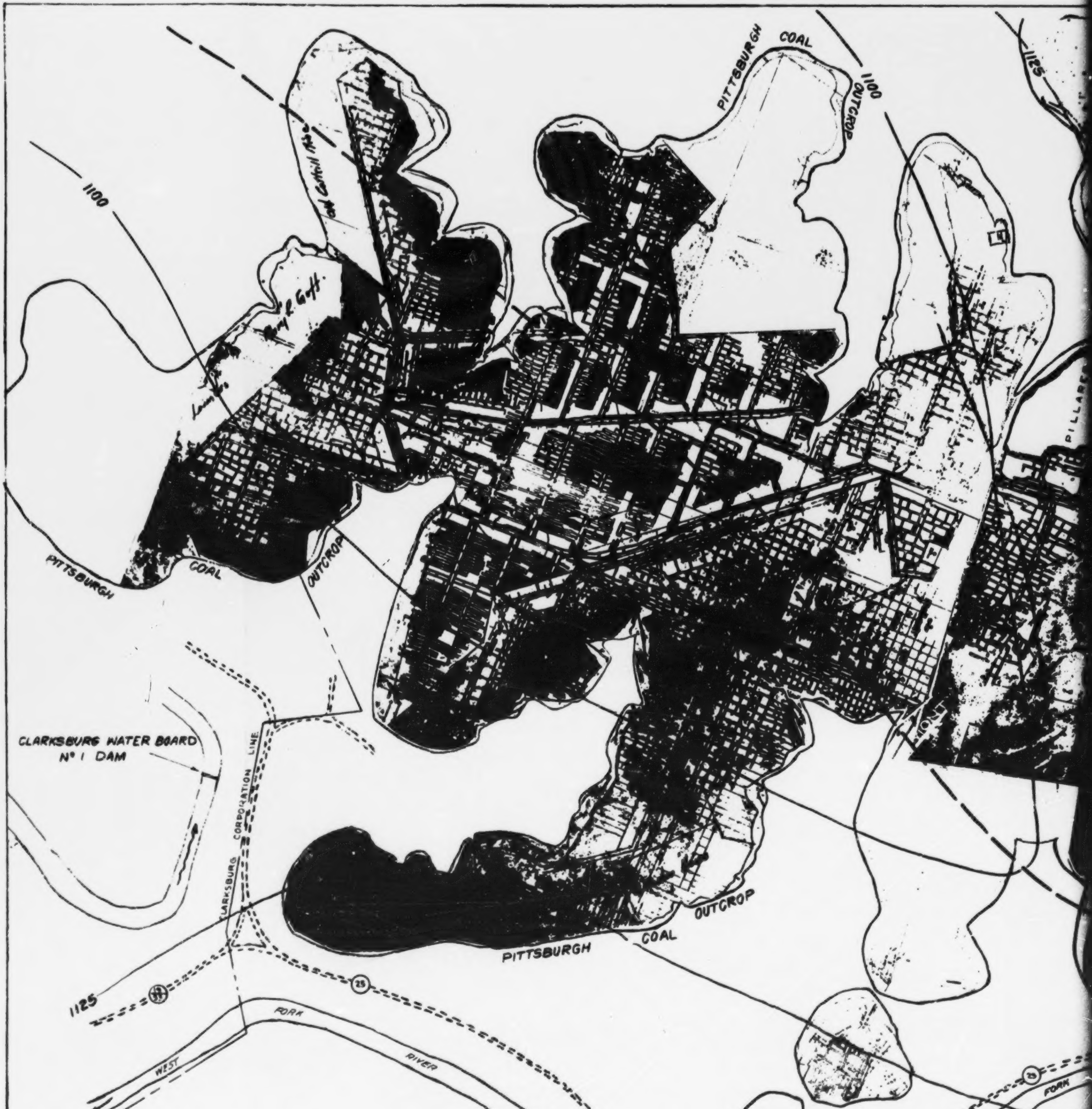
Figure 12 is a picture of a typical suspected opening in a stripped area which has been backfilled. This point has a drainage of acid mine water coming from under the backfill which has formed a marshy area in front of the backfill. This is located on the north side about midway up the hollow and is designated on Figure 9 as point "C". From observation of the mine map, the drainage appears to be coming from a line heading.

Throughout this area the Pittsburgh coal was augered where economically feasible. All the auger holes and most of the drift openings were covered by the backfilling operations, so the extent of possible drainage points is uncertain.

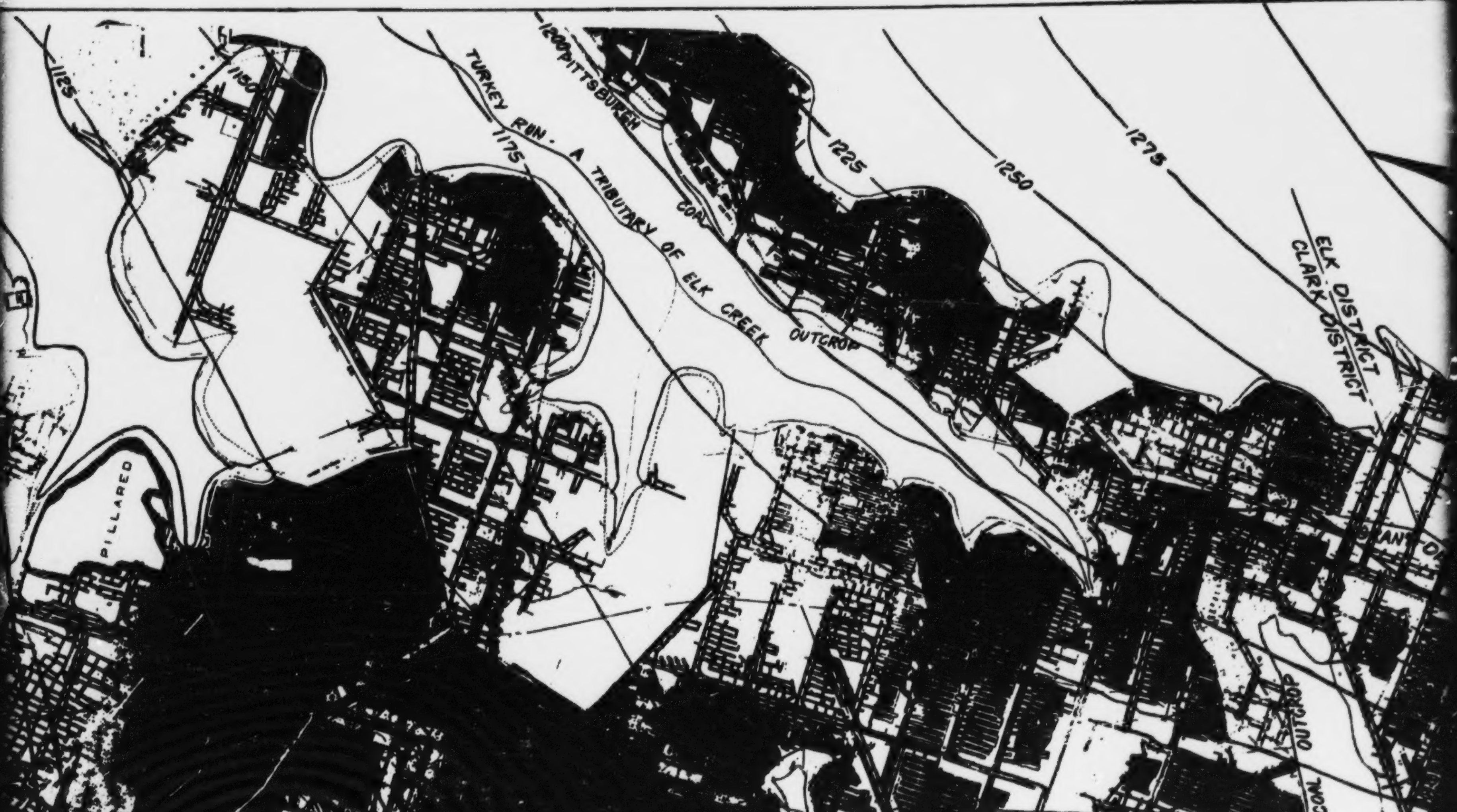
The thickness of the Redstone Coal along the highwall area in this survey was 2 feet and the thickness of the Pittsburgh coal seam was 8 feet. The average flow from mines in this area was 308 gallons per minute over a one-year period, with an acid contribution of over 8,900 pounds per month.

The second area surveyed was Hutchison Hollow which contained the Byron Mine complex (Mines No. 40-064 and 40-066). This hollow is in the central part of the Browns Creek area on the west side. In this area, 8,355 lineal feet of highwall were measured. A minimum of 60 drift openings were intersected during the stripping operations, including 5 which were not shown on the map. Several areas with pillars removed were noted on the map. This type opening would be very difficult to seal in an abatement program of any type.

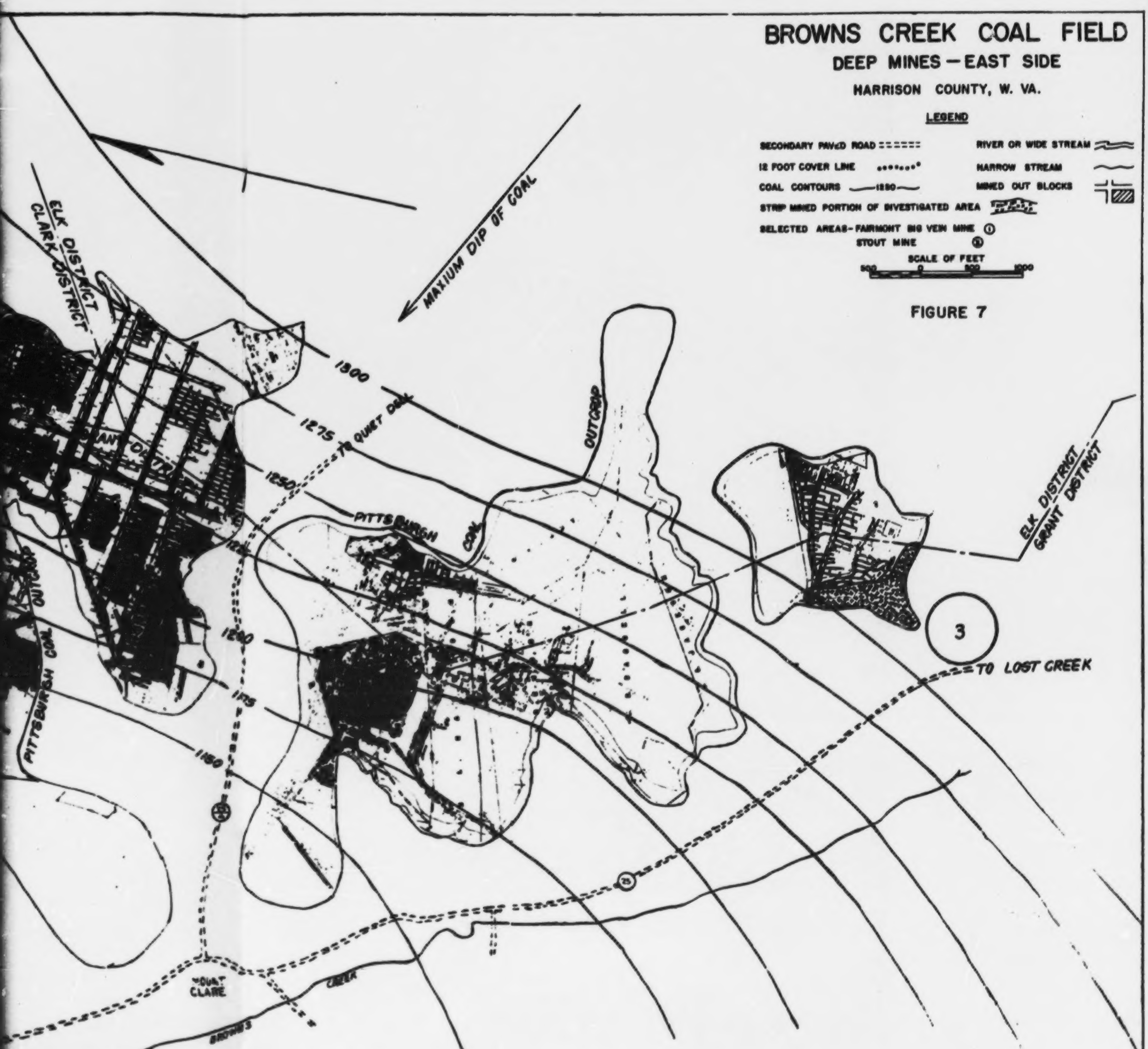
In addition to the Byron Mine complex, an occasional one-family mine was also discovered during the survey. The Pittsburgh


PITTSBURGH COAL OUTCROP
1100
1100
1125
1125
Geo. Cottrill Mine
Ray L. Goff
PITTSBURGH COAL OUTCROP
CLARKSBURG WATER BOARD
Nº 1 DAM
CLARKSBURG CORPORATION LINE
OUTCROP
PITTSBURGH COAL
25
WEST FORK RIVER
PILLARED
WEST FORK
CLA

A

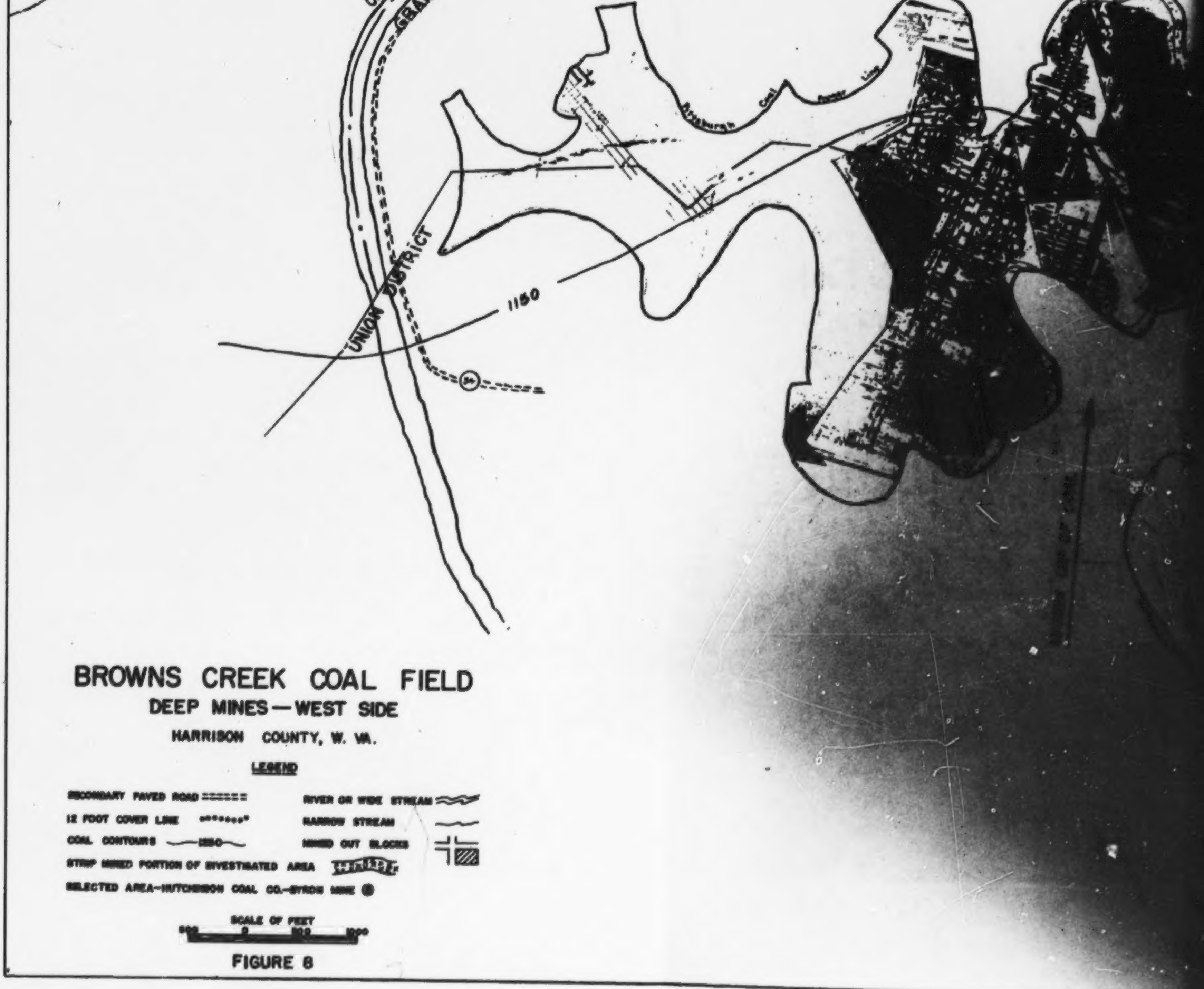

1125
1150
1175
1200 PITTSBURGH COAL OUTCROP
TURKEY RUN, A TRIBUTARY OF ELK CREEK
1225
1250
1275
ELK DISTRICT
CLARK DISTRICT
PILLARED
PITTSBURGH COAL OUTCROP
PITTSBURGH COAL OUTCROP
1
SHINNSTON
SYNCLI
FORK RIVER
CREEK
BROWNS
CLARKSBURG WATER BOARD
Nº 2 DAM
1125
25

B


LEGEND
SECONDARY PAVED ROAD
12 FOOT COVER LINE
COAL CONTOURS —1250—
STRIP MINED PORTION OF INVESTIGATED AREA
SELECTED AREAS- FAIRMONT BIG VEIN MINE
STOUT MINE
RIVER OR WIDE STREAM
NARROW STREAM
MINED OUT BLOCKS
SCALE OF FEET
500
0
500
1000
ELK DISTRICT
CLARK DISTRICT
MAXIUM DIP OF COAL
1300
1275
1250
1225
1200
1175
1150
TO QUIET DELL
PITTSBURGH COAL
OUTCROP
ELK DISTRICT
GRANT DISTRICT
3
TO LOST CREEK
PITTSBURGH COAL OUTCROP
25
MOUNT CLARE
BROWNS CREEK
SYNCLINE

BROWNS CREEK COAL FIELD
DEEP MINES — EAST SIDE
HARRISON COUNTY, W. VA.

FIGURE 7


WEST FORK RIVER
BROWNS CREEK
1125
1150
CLARK DISTRICT
GRANT DISTRICT
UNION DISTRICT
Pittsburgh Coal Power Line
36
34

BROWNS CREEK COAL FIELD
DEEP MINES—WEST SIDE
HARRISON COUNTY, W. VA.

LEGEND
SECONDARY PAVED ROAD
12 FOOT COVER LINE
COAL CONTOURS 1250
STRIP MINED PORTION OF INVESTIGATED AREA
SELECTED AREA-HUTCHINSON COAL CO.-BYRON MINE
RIVER OR WIDE STREAM
NARROW STREAM
MINED OUT BLOCKS
SCALE OF FEET
500 0 500 1000

FIGURE 8

A

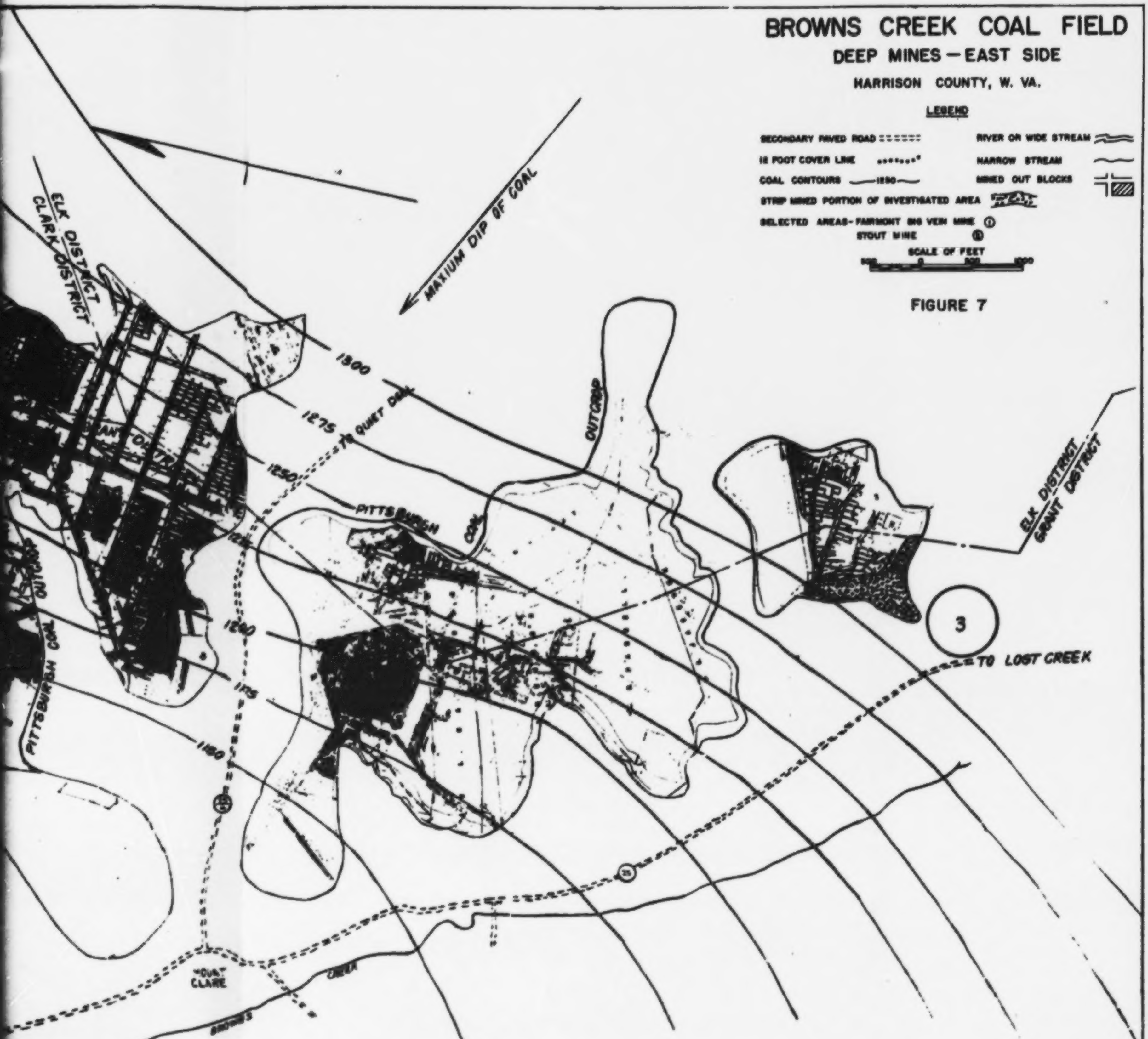
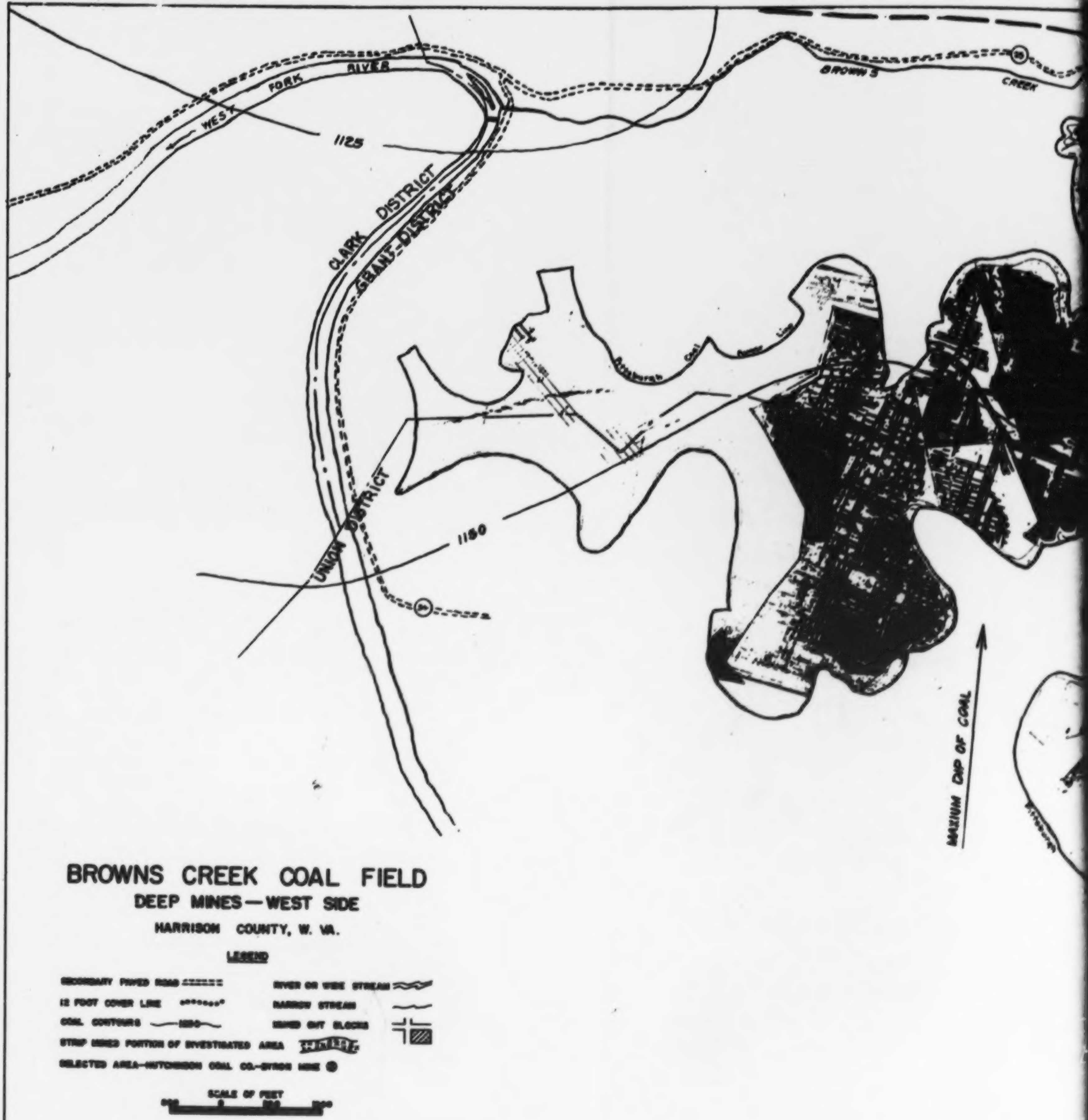

BROWNS CREEK COAL FIELD
DEEP MINES — EAST SIDE
HARRISON COUNTY, W. VA.
LEGEND
SECONDARY PAVED ROAD
RIVER OR WIDE STREAM
12 FOOT COVER LINE
NARROW STREAM
COAL CONTOURS —1250—
MINED OUT BLOCKS
STRIP MINED PORTION OF INVESTIGATED AREA
SELECTED AREAS - FAIRMONT BIG VEIN MINE ①
STOUT MINE
SCALE OF FEET
500
0
500
1000
ELK DISTRICT
CLARK DISTRICT
MAXIUM DIP OF COAL
1300
1275
TO QUIET DELL
1250
1225
1200
1175
1150
PITTSBURGH COAL OUTCROP
OUTCROP
PITTSBURGH COAL OUTCROP
ELK DISTRICT
GRANT DISTRICT
3
TO LOST CREEK
25
MOUNT CLARE
CREEK
BROWNS
SYNCLINE

FIGURE 7

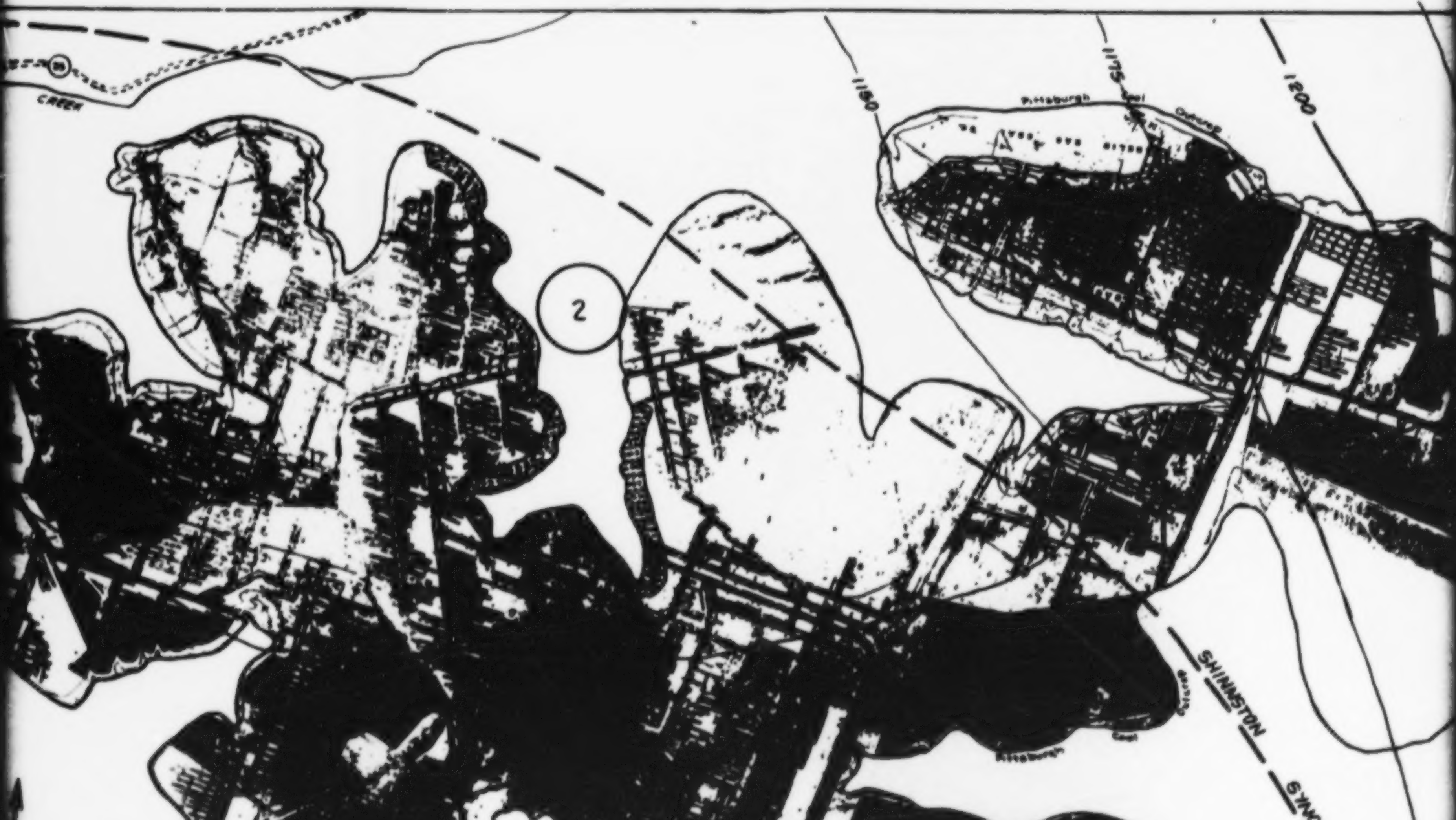


WEST FORK RIVER
BROWNS CREEK
1125
1150
CLARK DISTRICT
GRANT DISTRICT
UNION DISTRICT
Pittsburgh Coal Cover Line
MAXIUM DIP OF COAL
LEGEND
SECONDARY PAVED ROAD
12 FOOT COVER LINE
COAL CONTOURS
1150
STRIP MINED PORTION OF INVESTIGATED AREA
SELECTED AREA—HUTCHINSON COAL CO.—BYRON MINE
RIVER OR WIDE STREAM
NARROW STREAM
MINED OUT BLOCKS
SCALE OF FEET

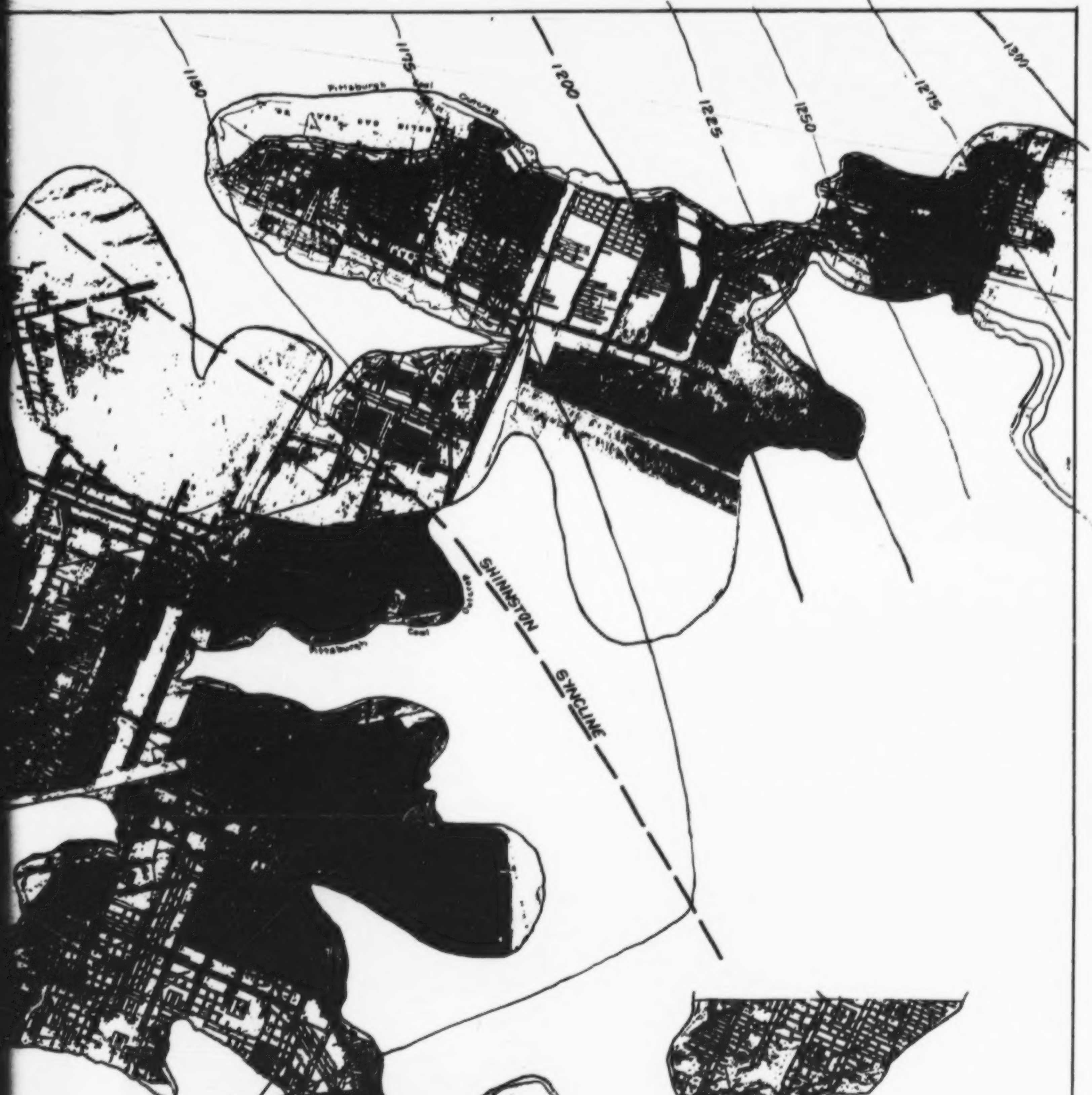
BROWNS CREEK COAL FIELD
DEEP MINES—WEST SIDE
HARRISON COUNTY, W. VA.

FIGURE 8

A

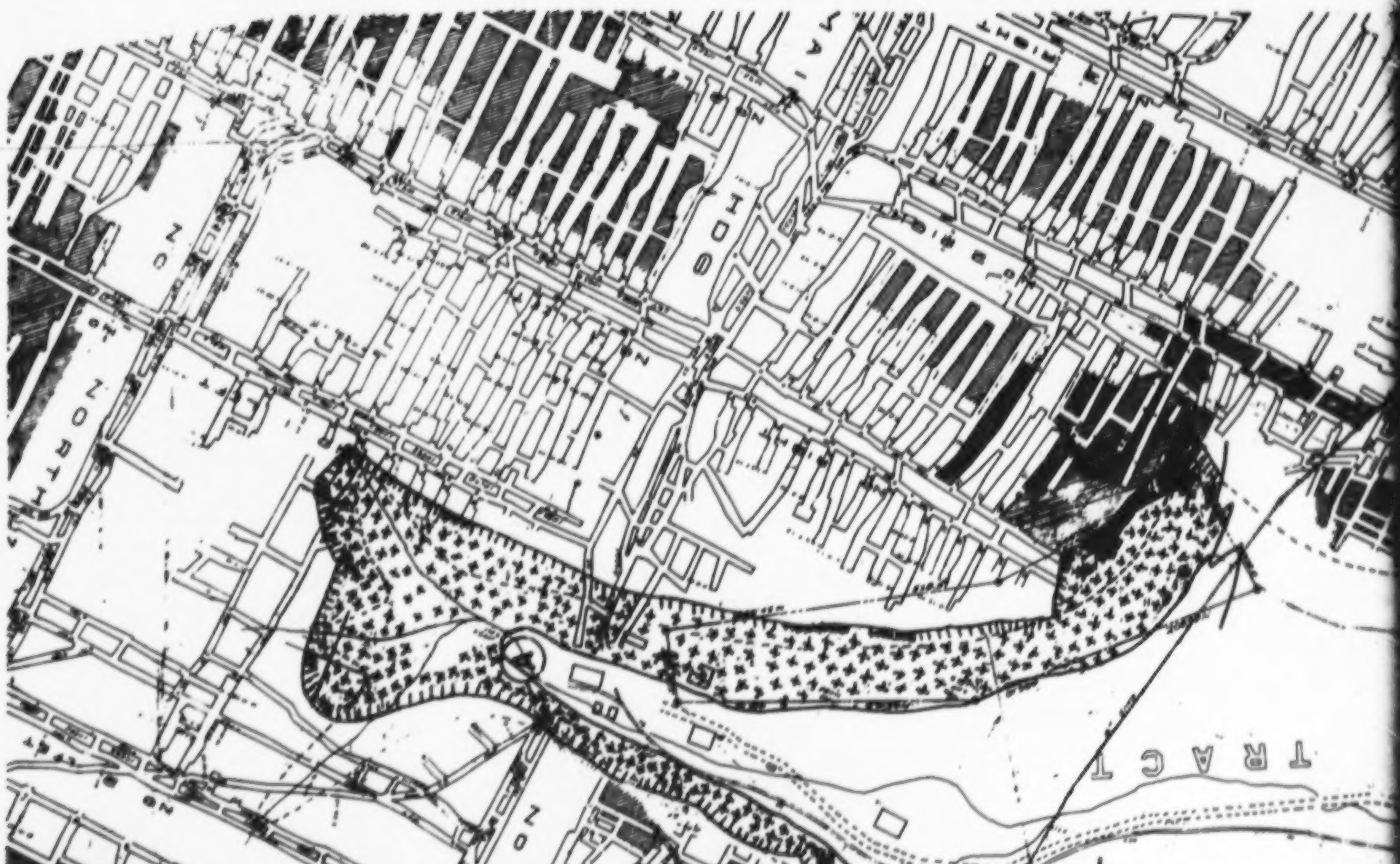

CREEK
Pittsburgh Coal Outcrop
1180
1175
1200
2
SHINNSTON SYNCLINE
Pittsburgh Coal Outcrop
Pittsburgh Coal Outcrop
1175
UNION DISTRICT
GRANT DISTRICT

B

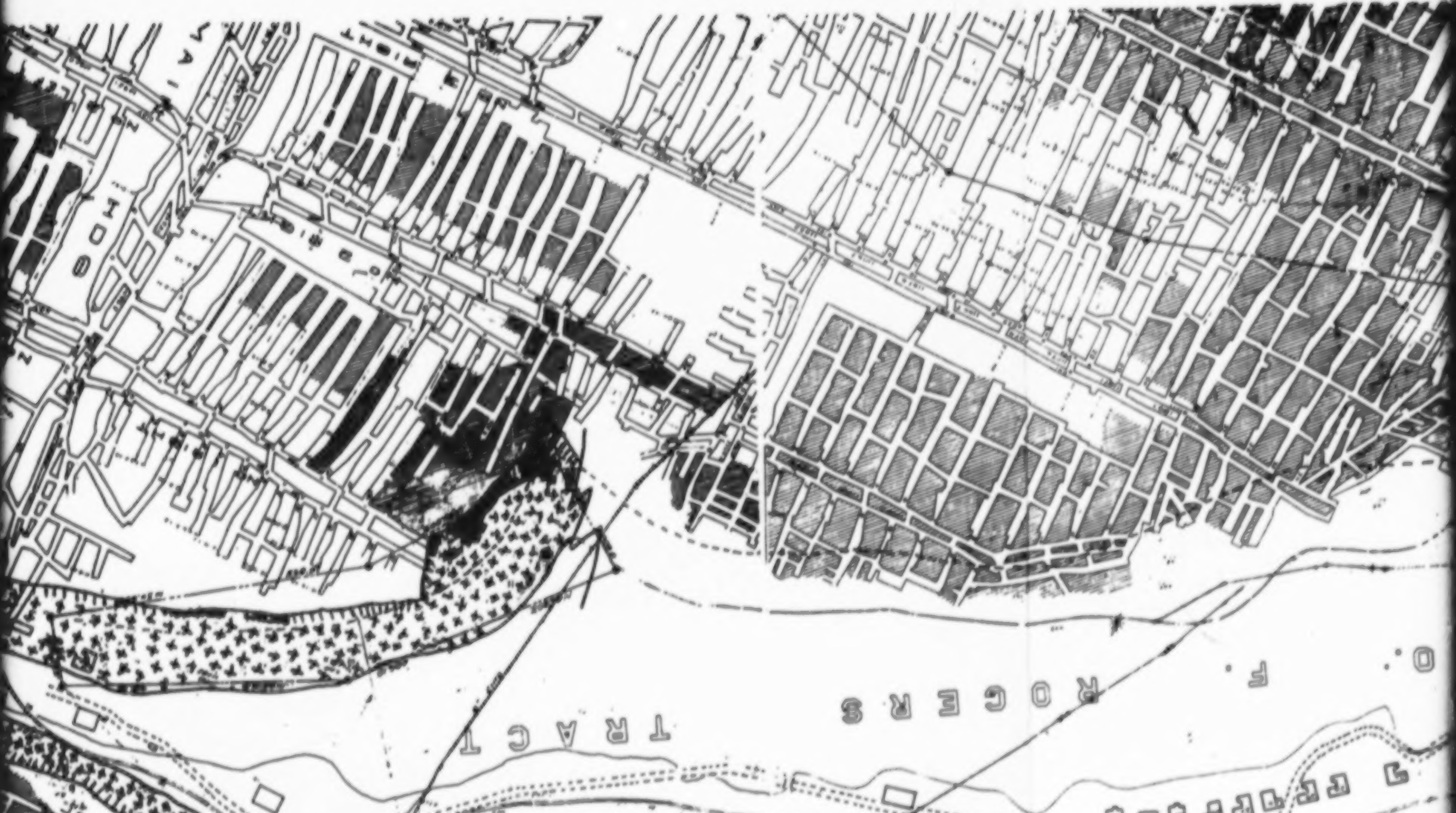


1150
1175
1200
1225
1250
1275
1300
Pittsburgh Coal Outcrop
SHINNSTON SYNCLINE
Pittsburgh Coal Outcrop
1175
UNION DISTRICT
GRANT DISTRICT

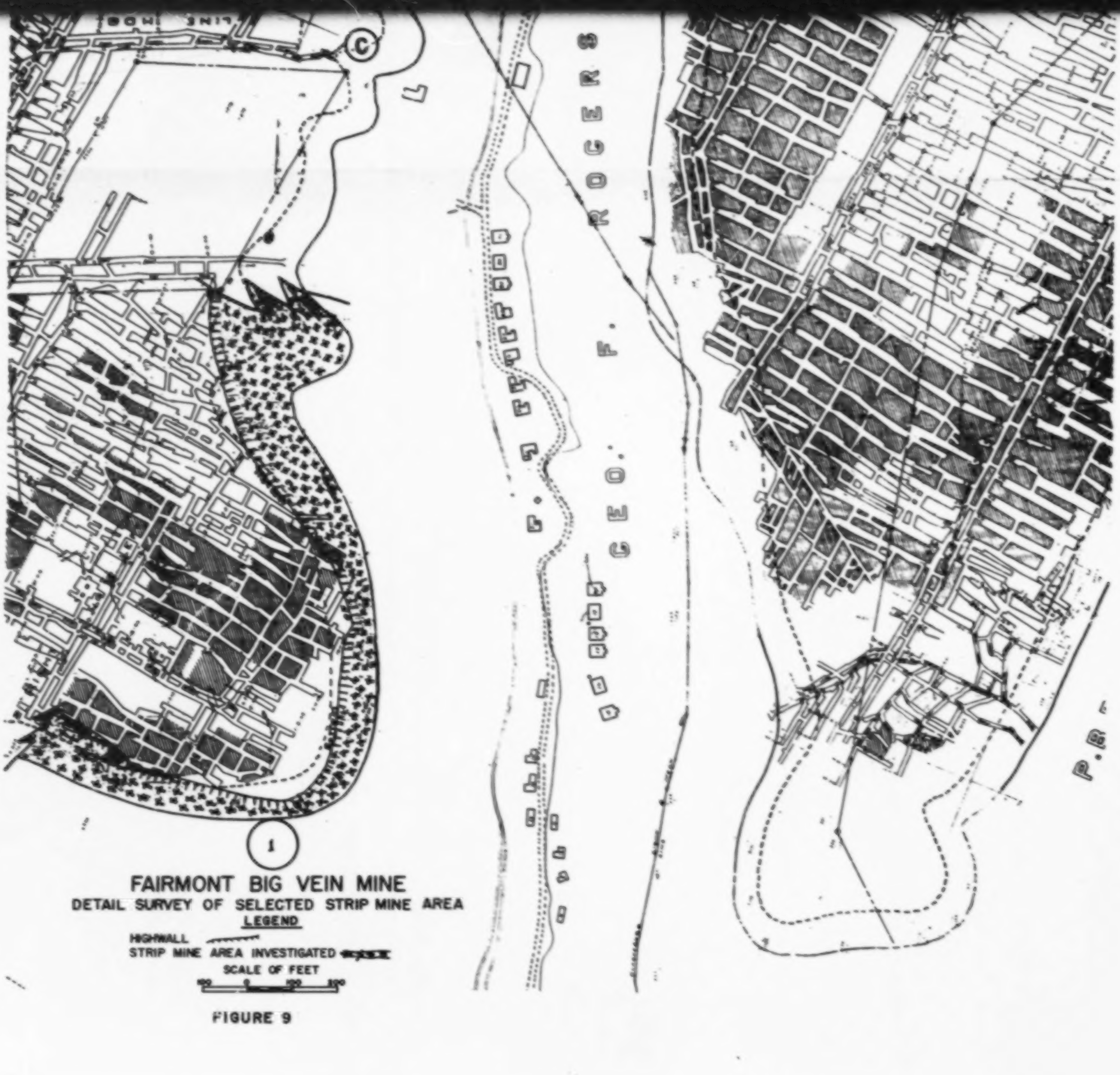
C


NORTH
MAI
TRACT
C.F. ROGERS
RESERVATION
A
B

A


MAIN
C.F. ROGERS
RESERVATION
TRACT
ROGERS
F.
O.
L
LINE HWY
SOUTH
B
C

B


GEO. F. ROGERS
C
L
1
P. R.

FAIRMONT BIG VEIN MINE
DETAIL SURVEY OF SELECTED STRIP MINE AREA

LEGEND
HIGHWALL
STRIP MINE AREA INVESTIGATED
SCALE OF FEET
100 0 100 200

FIGURE 9

B

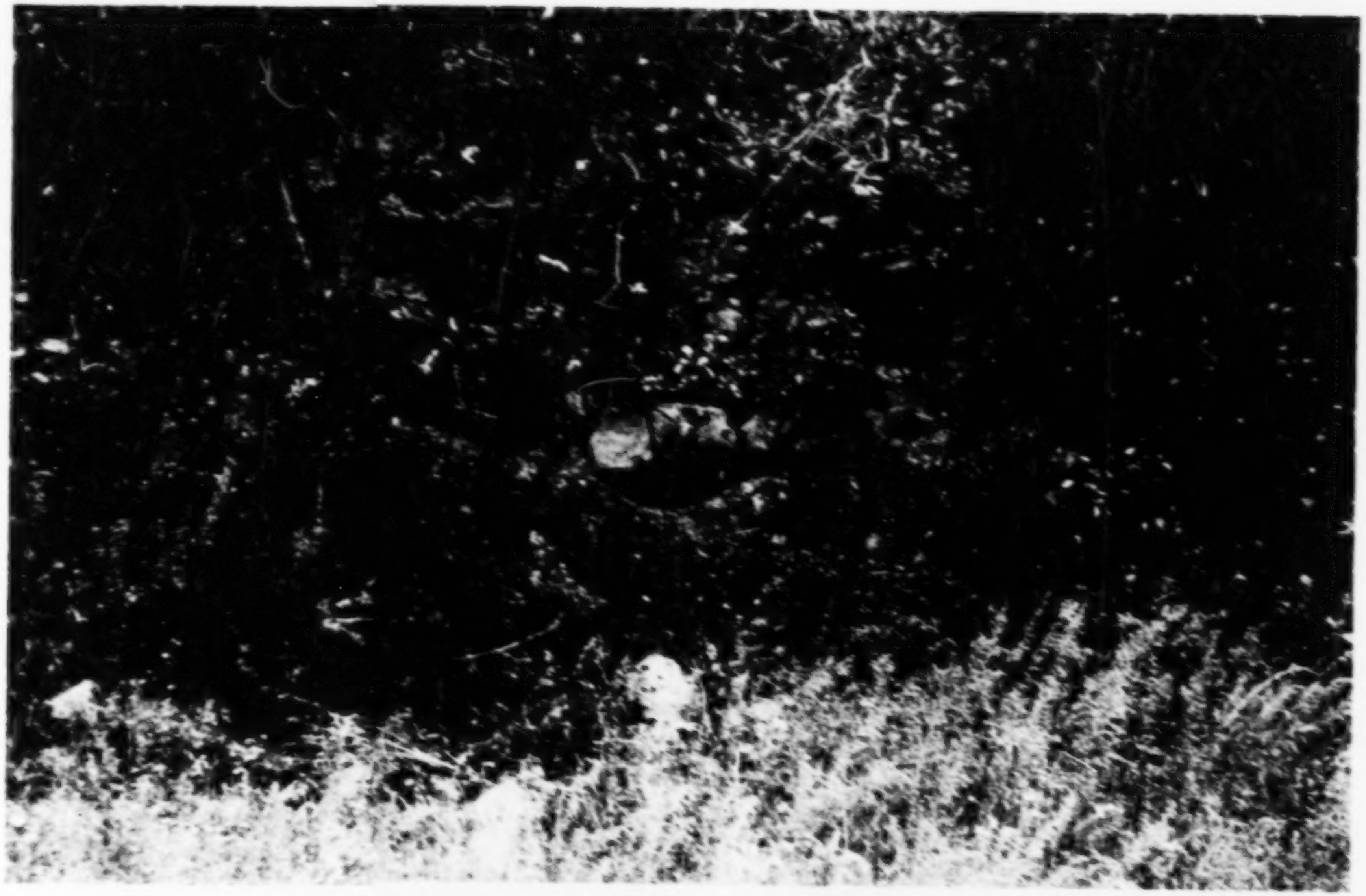


FIGURE 10 - VOID IN HIGHWALL ABOVE RECLAMATION BACKFILL

FIGURE 11 - VOID IN HIGHWALL - FAIRMONT BIG VEIN MINE

FIGURE 12 - SUSPECTED OPENING DRAINING UNDER BACKFILL

coal was 8 feet thick in the mine complex and was augered where economically feasible. Redstone coal was in thin sections from 6 inches to 2 feet thick. As was true in the other areas surveyed, the physical characteristics of exposed openings were bad and in many places were collapsed. Figure 13 is a detailed mine map with the stripping area and the bottom of the highwall line shown on the map to determine the points of intersection with the drift openings of the mine. This area was a large contributor of acid mine water, flowing an average of 302 gallons per minute over a one-year period and contributing 10,339 pounds of acid per month to Browns Creek.

A fanway opening was listed on the original Monongahela Survey as part of Mine No. 40-066. About 100 feet southwest of this fanway is a timbered portal to a family mine which is still mined by hand and wheelbarrow methods. Figure 14 shows this portal. Note that the stripped highwall has been partially backfilled. A slight drainage is noted from the opening. The fanway is denoted as point "A" and the portal as point "B" on the mine map, Figure 13. These openings are not indicated on the mine map of the area.

Figure 15 shows acid mine drainage coming from abandoned deep mines in the hollow. This hollow also contains several inhabited dwellings. Figure 16 is a view looking up the north arm of the stripped area which shows numerous gob piles remaining from the deep mining operations.

Remains of the original heading openings which were driven into the outcrop of the Pittsburgh coal are shown in Figure 17 and denoted on the mine map as point "C". The two concrete openings now stand approximately 125 feet in front of the highwall because of the removal of the Pittsburgh coal by the stripping operation. Figure 18 shows three openings exposed by stripping. The two openings on the right are above the headings for the openings shown in Figure 17. The base of the Pittsburgh coal is approximately 20 feet below these openings beneath the backfill. These openings are shown on the mine map (Figure 13) as point "D". The formations above the Pittsburgh coal have collapsed to create the void spaces which are evident in Figure 18. This condition is similar to that found in Two Lick Hollow on the east side of Browns Creek and is prevalent throughout the Browns Creek Coal Field. A geologic section for this mine complex is included in the Appendix as Figure 29.

The third area which was surveyed was on the east side of Browns Creek near the headwaters. This was an island-type mine known as the Stout Mine, or Mine No. 40-058. A total of 1,300 lineal feet of highwall was measured in the survey. A detailed map of the mine workings for this mine, with the stripping area and the bottom of the highwall line shown marked on the map, is attached as Figure 19. A minimum of 7 drift openings were intersected by the stripping. Some of the drifts, indicated by dotted lines on the map, are drifts which were inaccessible to the engineers who made the map, so the extent of the opening uncovered by the stripping is unknown.

Figure 20 shows the reclamation backfill against the highwall where considerable drainage is flowing under the coarse rubble which has sloughed off the highwall. This area is denoted on the mine map as point "A". The map reveals that the drainage is apparently coming from two hidden drift openings of the main heading and a line heading.

Figure 21 shows the backfilled highwall on the west side of the Stout Mine. This area is denoted on the mine map as point "B". The map shows that the stripping cut into a complex of deep mine drifts. This is further substantiated by the deteriorated highwall and subsidence below the limestone ledge. The Pittsburgh coal base is approximately 20 feet below the top of the backfill. A geologic section of the Stout Mine is included as Figure 30 in the Appendix.

This area contributed an average flow of 289 gallons per minute over the one-year monitoring period containing 3,678 pounds of acid per month.

Another important factor which must be considered in planning any abatement program for this or similar areas is the presence of thin sections in the existing highwalls. This situation resulted where stripping had been extensive after drift mining, and could cause serious problems of leakage or flooding if water trapped either naturally or by bulkhead seals inside a mine obtained sufficient head to create a breakout.

There were three survey methods utilized during this phase of the contract. The initial survey by a reconnaissance party was limited in results to observation of physical conditions, such as exposed openings, drainage from under backfill, mining equipment and construction still in evidence, subsidence, etc. The probing method with a power driven auger was unsuccessful in determining location or extent of hidden openings. The method of surveying the existing highwall line created by the strip mining method and plotting the highwall line onto a mine map was thoroughly investigated. This method was useful in determining the possible existence of many of the suspected hidden drift openings. The positive way of locating suspected drift openings would be by removing the backfill placed against the highwall at the time of strip mine reclamation. However, the cost of this method would be prohibitive.

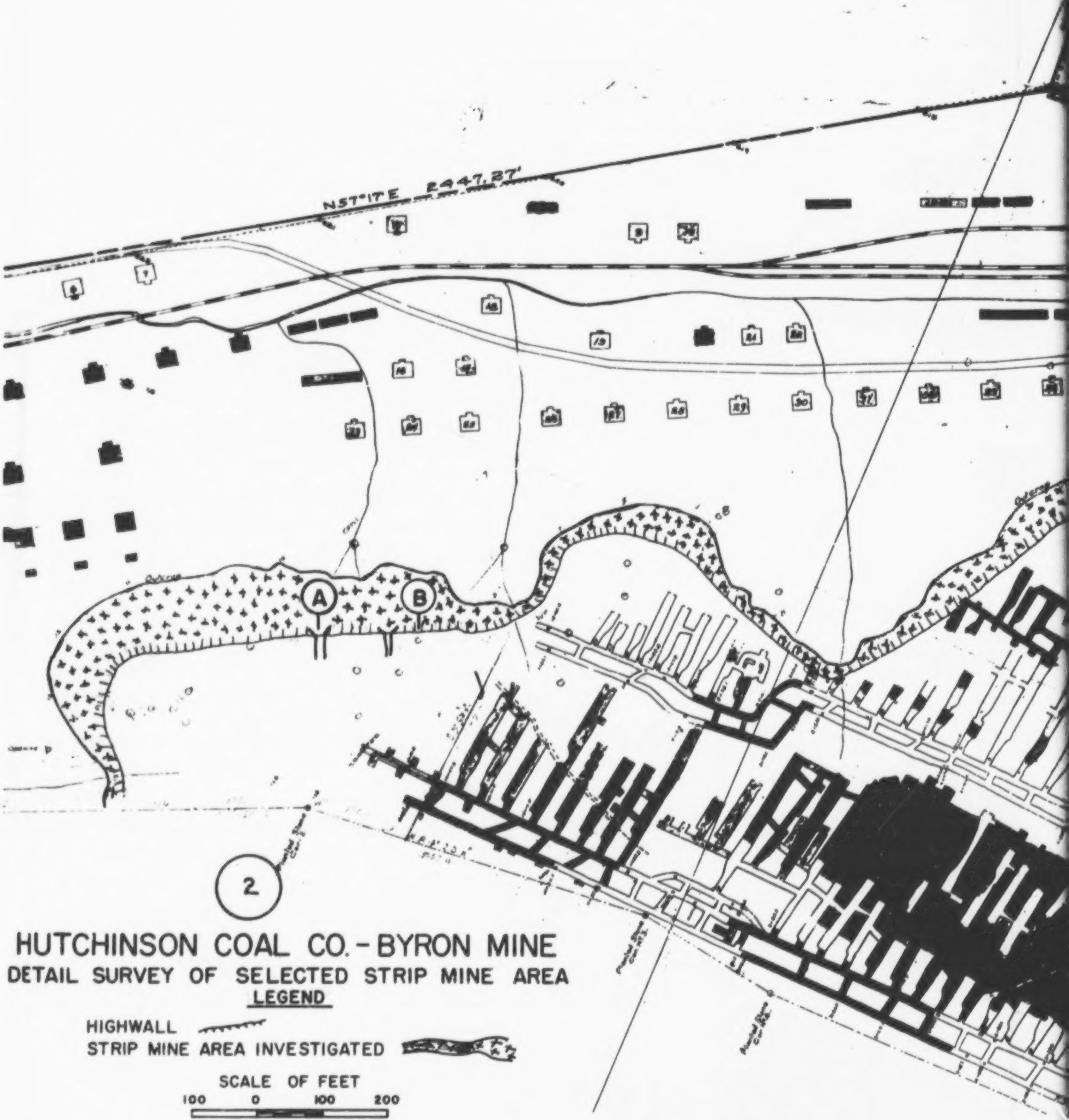
Some need for reclamation does remain in certain mine areas. Views of Mine No. 40-081 attached as Figures 22 and 23 show this site which has not been reclaimed. Gob piles from deep mining operations are in evidence over the area. Drift mine openings into the highwall with rail tracks and abandoned cars are also noted in Figure 23.

The investigative work accomplished during this phase revealed the complexity of the pollution abatement problem for the Browns Creek area. Subsidence was evident extensively throughout the watershed. The area had hundreds of openings which would require sealing. Many of these were buried beneath backfills in the stripped areas, and some were drifts or crosscuts exposed lengthwise which would present a very difficult sealing problem. Some openings were found which were not shown on available mine maps. Some of the drifts which were shown by the land survey map to have been intersected by the stripping were identified visually in each area. It can be noted on the composite mine map of the east side of Browns Creek (Figure 7) that the mine complexes north of Route 25 appear to be interconnected beyond the mouth of Browns Creek. The coal dips 175 feet through this area.

In summary, the foot reconnaissance party did locate unknown or hidden openings. An additional 30 openings were discovered besides the 51 previously located by the Monongahela Survey. These 30 openings were marked on a map and physical characteristics compiled. Attempts to locate openings using power driven augers were not successful.

Another approach was employed in an attempt to find a better method for locating hidden openings. A land surveying party determined the bottom of the highwall line in three selected areas. This information was then plotted on an old mine map to show where stripping intersected underground mines. A minimum of 107 openings were shown to be intersected in these three areas. Photographs are included for some points where openings were found which correspond to those marked from this survey.

Although the investigation specified for this phase in the Statement of Work was accomplished, this only gave an indication of the abatement work which would be required should a remedial program be desired which would encompass the entire Browns Creek Coal Field.


N57°17'E 2447.27'
Outcrop
A
B
2

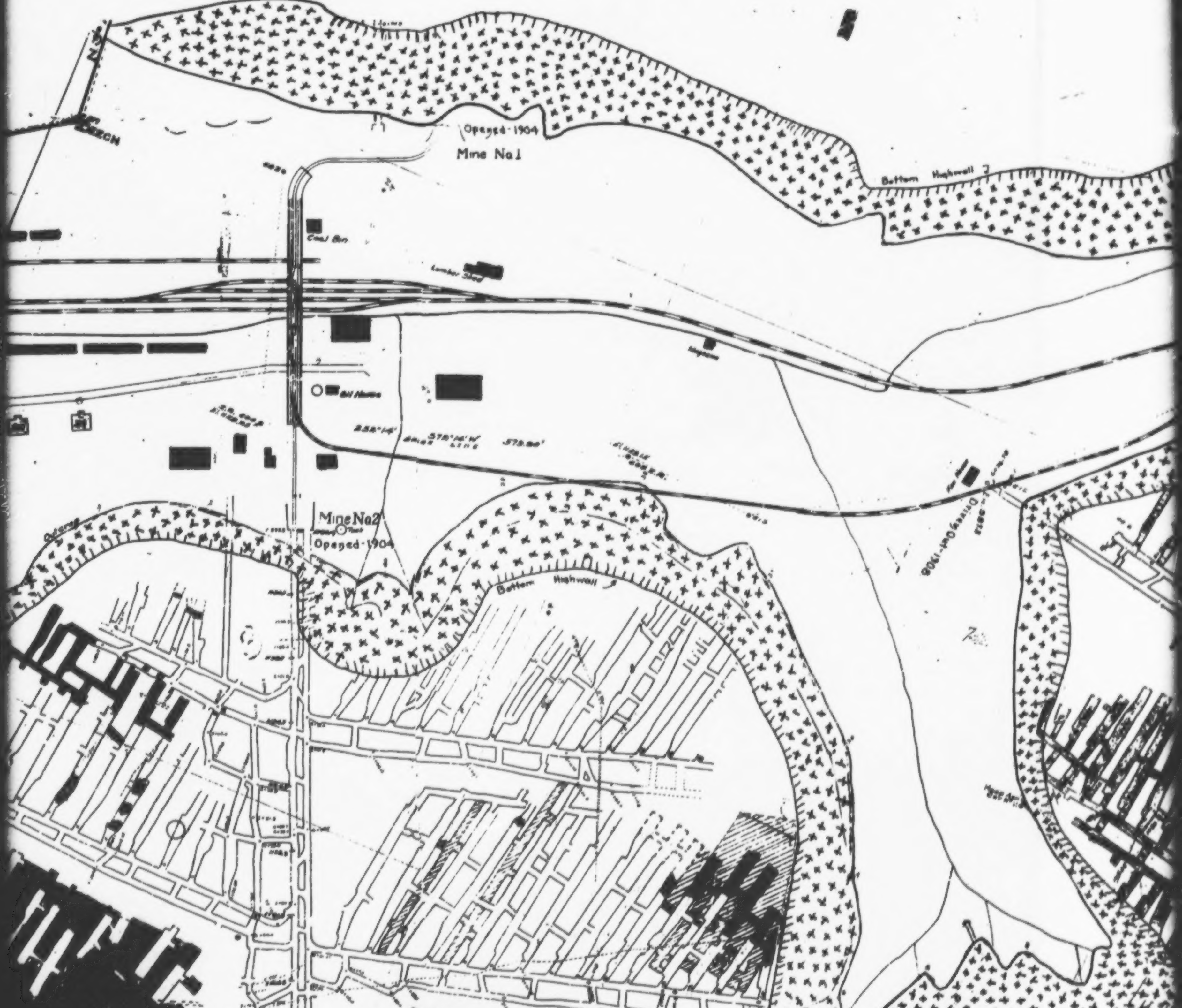
HUTCHINSON COAL CO. - BYRON MINE
DETAIL SURVEY OF SELECTED STRIP MINE AREA

LEGEND

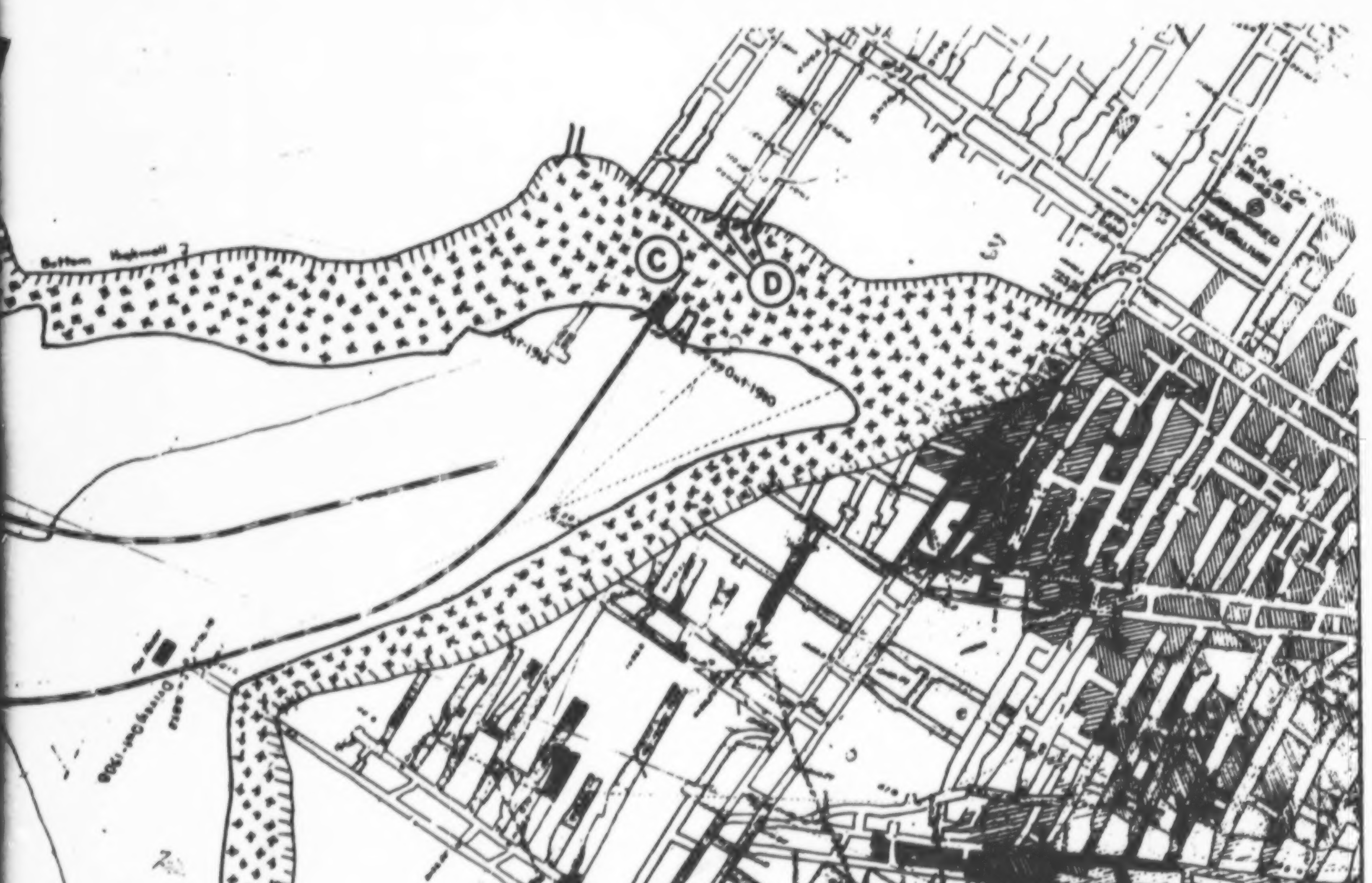
HIGHWALL
STRIP MINE AREA INVESTIGATED

SCALE OF FEET
100 0 100 200

FIGURE 13


Opened-1904
Mine No.1
Coal Bin
Lumber Shed
Oil House
Bottom Highwall
Magazine
S78°14'W
573.50'
Mine No.2
Opened-1904
Bottom Highwall

B


Bottom Hopewell 7
C
D
Oct 1960

C

FIGURE 14 - TIMBERED PORTAL - ONE-FAMILY MINE

FIGURE 15 - ACID MINE DRAINAGE FLOWING FROM HUTCHISON HOLLOW

FIGURE 16 - VIEW OF NORTH ARM OF STRIPPING AREA - HUTCHISON HOLLOW

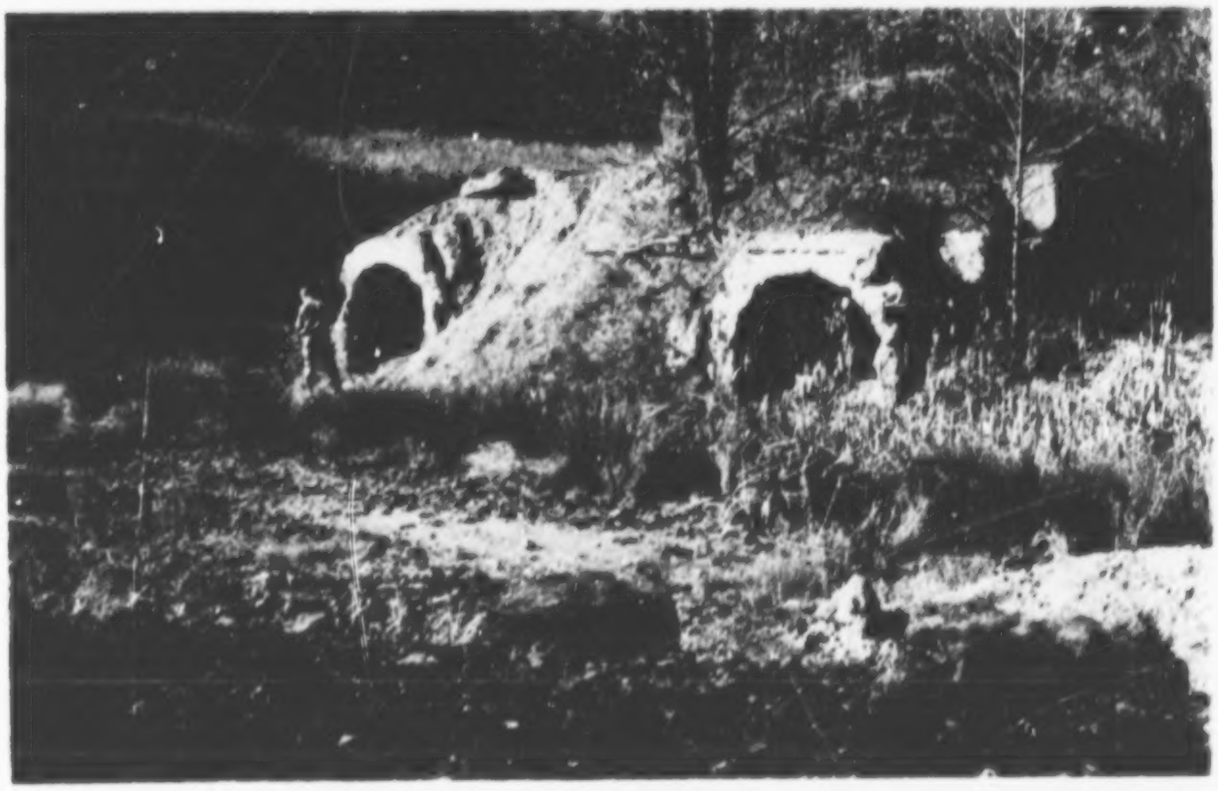


FIGURE 17 - REMAINS OF ORIGINAL MAIN HEADINGS - MINE NO. 40-066

FIGURE 18 - OPENINGS IN HIGHWALL EXPOSED BY STRIPPING

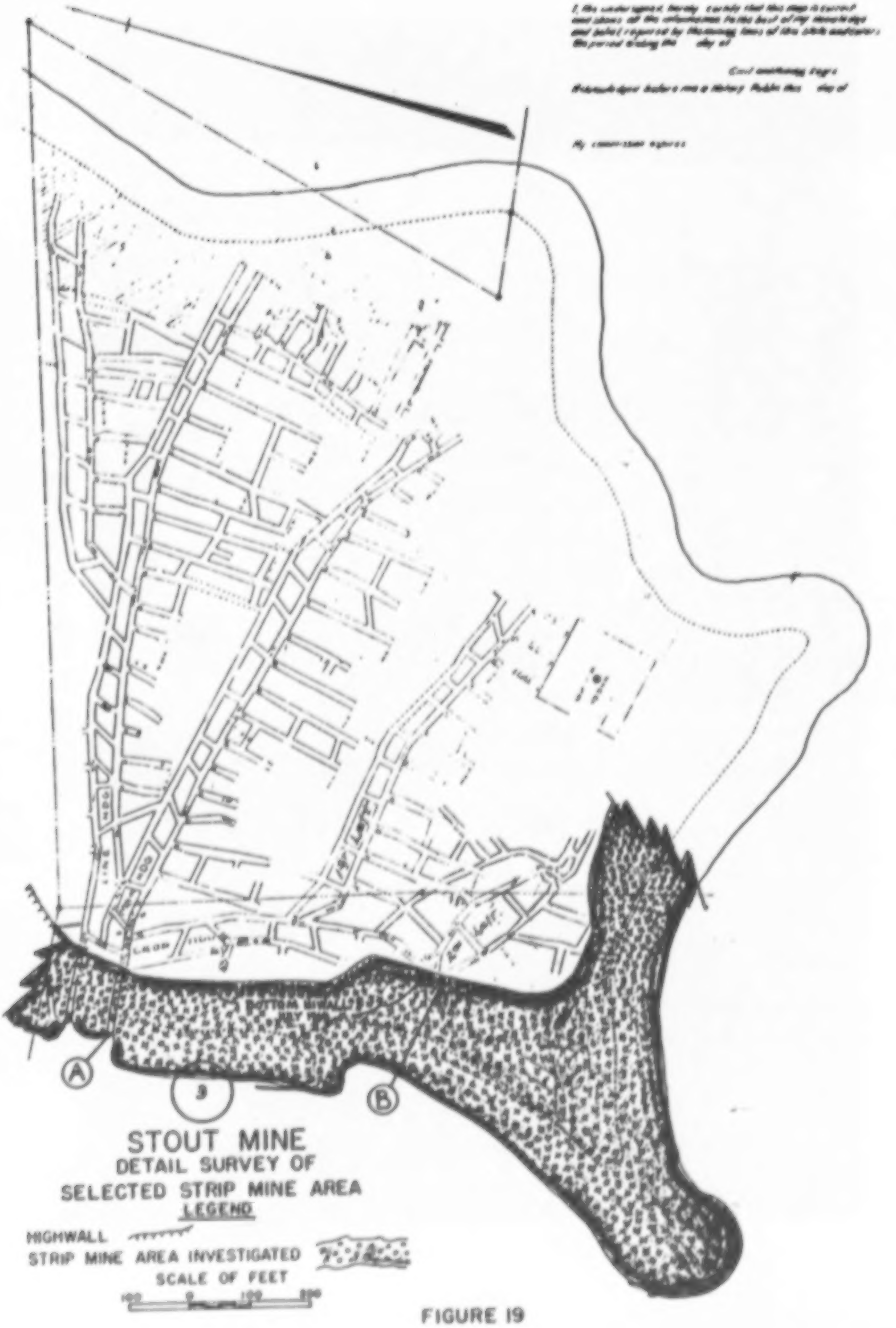

A
3
B
STOUT MINE
DETAIL SURVEY OF
SELECTED STRIP MINE AREA
LEGEND
HIGHWALL
STRIP MINE AREA INVESTIGATED
SCALE OF FEET
100
0
100
200

FIGURE 19

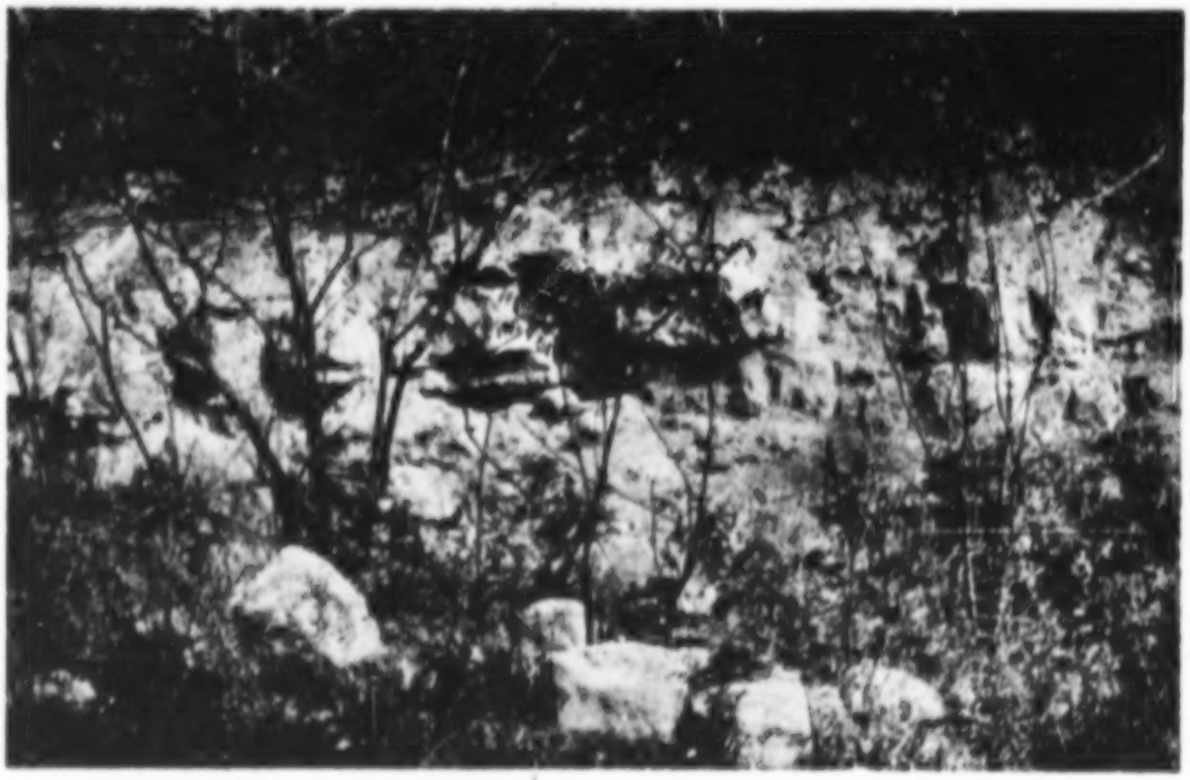


FIGURE 20 - HIGHWALL WITH COVERED OPENINGS - STOUT MINE

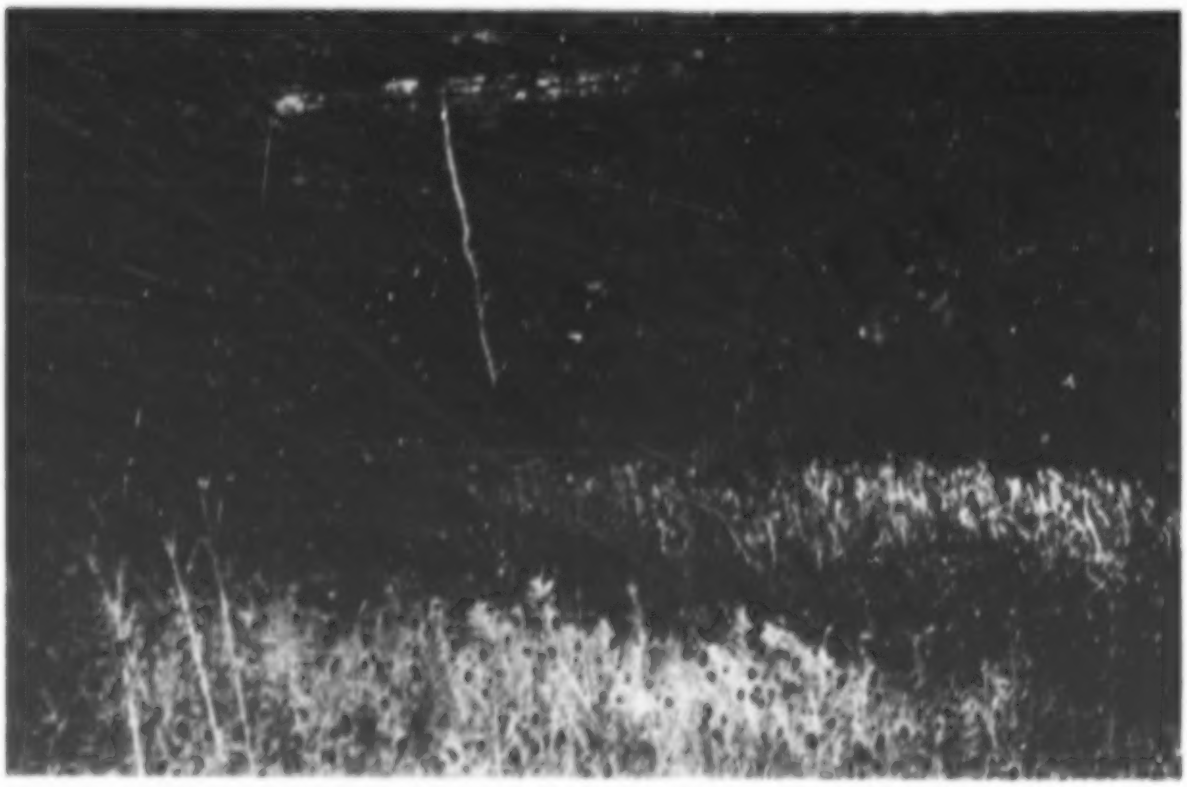


FIGURE 21 - SUBSIDED HIGHWALL AREA - STOUT MINE

FIGURE 22 - TYPICAL STRIP AREA - NO RECLAMATION

FIGURE 23 - PARTIALLY EXPOSED DRIFT OPENINGS IN HIGHWALL

EFFECTS OF MINING ON SUBSURFACE WATER

This phase of the project was undertaken to develop background data for improved knowledge of the subject of mine drainage and to provide a better basis for future abatement projects. An unmined isolated area, unaffected by mining, was selected for stream sampling and analysis to compare water quality with that of a nearby mined area. To obtain comparative data, a water table in an unmined area and one in a mined area were monitored, sampled and analyzed.

One well was drilled in an unmined area to a depth below the Pittsburgh coal seam and another well in a mined area used in a previous contract was deepened to a depth below the Pittsburgh coal seam. Both wells were drilled and equipped identically.

An unmined area located in Warren District, Upshur County, West Virginia was selected for the site of one well. This site, on the headwaters of an unnamed tributary to Rooting Creek, was selected because of similar geological conditions to the mined area. Figure 24 shows the location and plat of the site.

A survey was made and the following elevations were determined:

Well Site - - - - - - - - - - - -	-1301.73
Top of Redstone Coal Outcrop- -	-1281.73
Top of Pittsburgh Coal Outcrop-	-1229.51

A rotary-type drilling rig was moved on location to drill the well. A view of the drilling site showing the topography of the location is attached as Figure 25.

Drilling was initiated using a 5-5/8-inch OD bit to drill the pilot hole. A show of water was encountered at 19 feet just above the Redstone Coal. Water increased as the hole was drilled from 32 to 42 feet in depth. At a depth of 50 feet, drilling was stopped overnight. There was 40 feet of water in the hole the following morning. Drilling was continued to 80 feet and then the hole was reamed to 7-3/8 inches in diameter. Pittsburgh Coal was found from 62 to 63-1/2 feet. The hole was cased by seating 6-inch OD water well casing at 80 feet. Water was blown from the hole and drilling continued using a 5-1/2-inch OD bit. Hole was drilled to a depth of 182 feet with no additional signs of water. A driller's log is included in the Appendix as Table 12 and a geologic section for this well is included as Figure 31.

The mined area selected for study was Mine No. 62-009, northwest of Lost Creek, West Virginia. This mine is on the back side of Mine No. 62-008 which was previously described. This discussion would also apply to Mine No. 62-009. A hole drilled on a previous contract was utilized for this study. This hole, designated as No. 3 in a group of 8, had a 6-inch diameter hole to a depth of 88-1/2 feet. Figure 26 shows the location and plat of this well and location of sampling stream. Elevation of the site is approximately 1020 feet.

A cable-tool type drilling rig was used to ream the 6-inch hole to 10 inches diameter and continue drilling to a depth of 152 feet. A string of 5-1/2-inch OD, 17 lbs/ft, J-55 steel casing was seated at 113 feet. A 4-7/8-inch bit was then used to drill the hole to a total depth of 227 feet. Redstone Coal was found from 68-1/2 to 76-1/2 feet. Pittsburgh Coal was located from 97 to 103 feet.

During the drilling, static tests were made to check on water influx to the hole by stopping the drilling and measuring fill-up in the hole after a given time. Results were as follows:

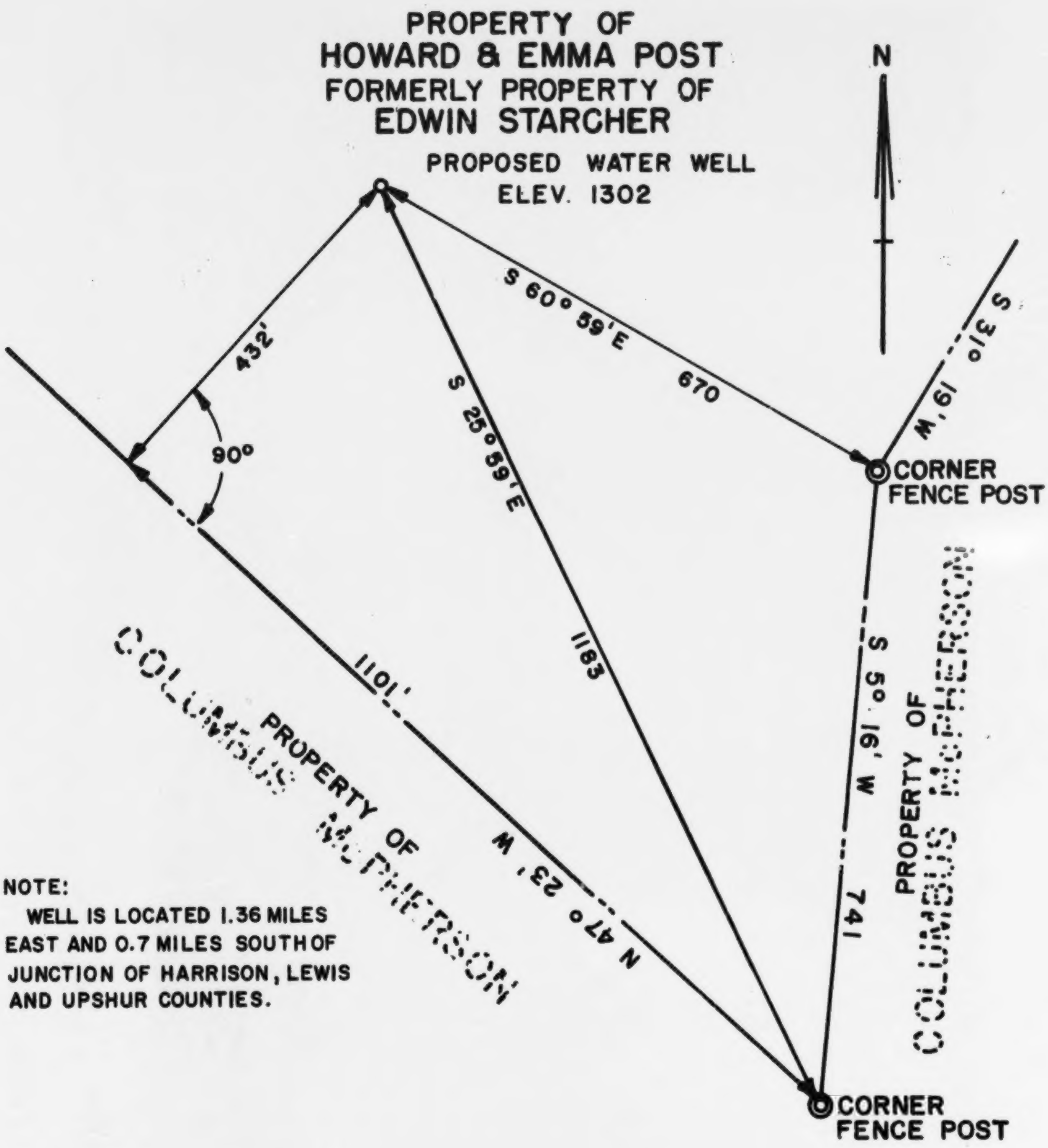
Depth (feet)	Downtime (hours)	Water in Hole (feet)	Water in Hole (gallons)	Influx (gal/hr)
152	16	12	11.6	0.73
183	41	45	43.6	1.06
211	17	41	39.7	2.33

This test showed that the deeper formations produced water at a faster rate than the shallower formations.

A driller's log for this well is included in the Appendix as Table 13 and a geologic section of this well is included as Figure 32.

Monitoring of each well and an adjacent stream was continued throughout the duration of the project. A Stevens Type F Water-level Recorder was installed on each well to continuously record the water level. The fluid level in each well and the flow in the adjacent streams are tabulated in Table 14 of the Appendix.

A plot of the data on water levels in the two wells and flow in adjacent streams is attached as Figure 27. It can be seen that the water levels are highest in the initial monitoring done in December and January, then decline and level off about May for the balance of the monitoring period. The level in the well at Mine No. 62-009 raised 18 feet from January 12, 1969 to May 5, 1969 and remained at that level during the next 4 months of monitoring. The water level in the well at the unmined area raised 48 feet in the same period and also remained static during the following 4 months. Since the middle of February, the level of the unmined area well has been higher than that of the mined area by about 3 feet. This seems to show that the water level will be lower in the mined area, although it is difficult to compare these two wells since they are several miles apart.


PROPERTY OF
HOWARD & EMMA POST
FORMERLY PROPERTY OF
EDWIN STARCHER
PROPOSED WATER WELL
ELEV. 1302
N
432'
90°
S 60° 59'E
670
S 25° 59'E
1183
S 31° 19' W
CORNER FENCE POST
1101'
N 47° 23' W
PROPERTY OF
COLUMBUS McPHERSON
PROPERTY OF
COLUMBUS McPHERSON
S 5° 16' W
741
CORNER FENCE POST

NOTE:
WELL IS LOCATED 1.36 MILES EAST AND 0.7 MILES SOUTH OF JUNCTION OF HARRISON, LEWIS AND UPSHUR COUNTIES.

PLAT-WATER WELL
UNMINED AREA
WARREN DIST., UPSHUR COUNTY, WEST VA.
SCALE: 1" = 200'

FIGURE 24

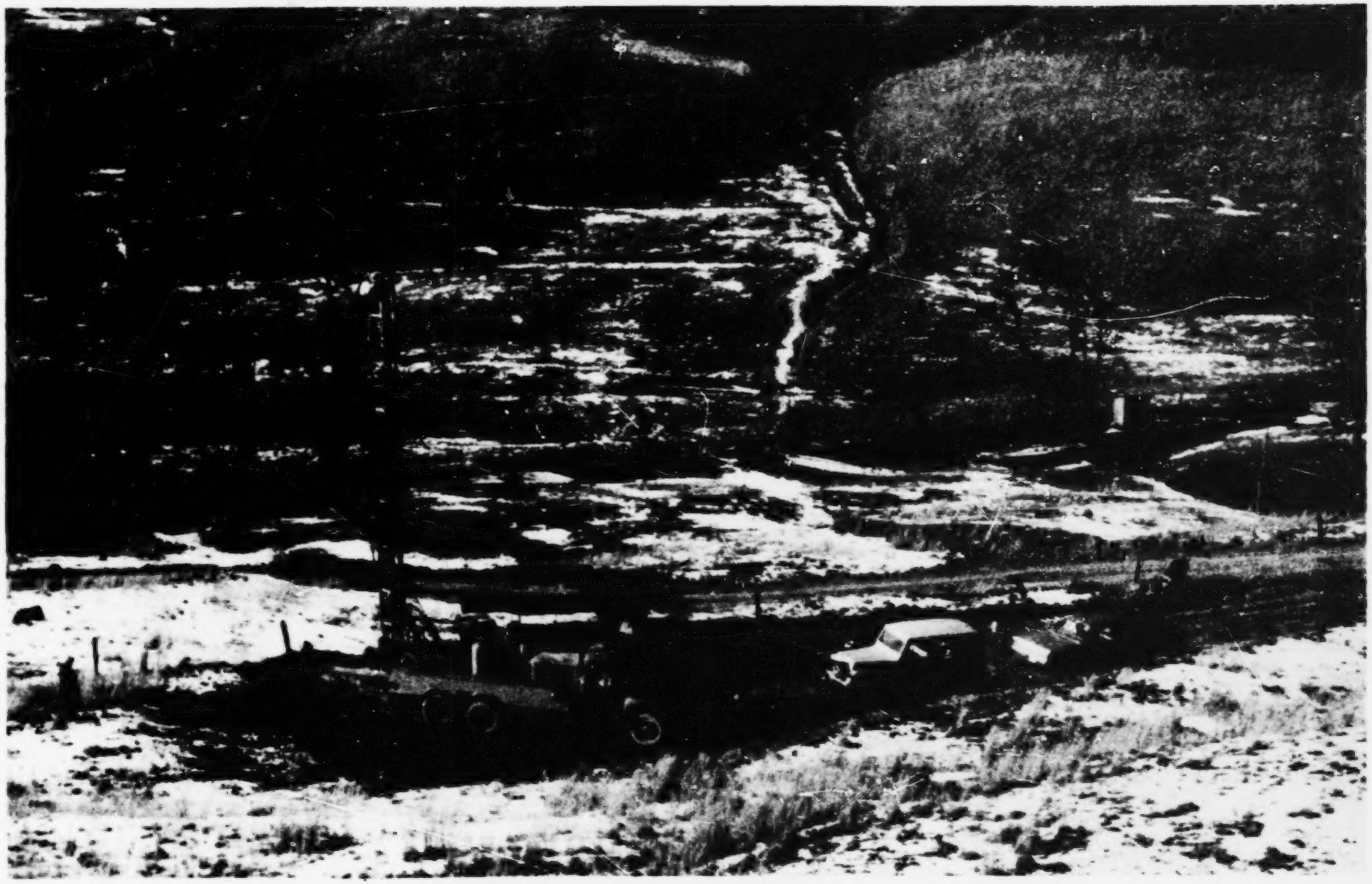
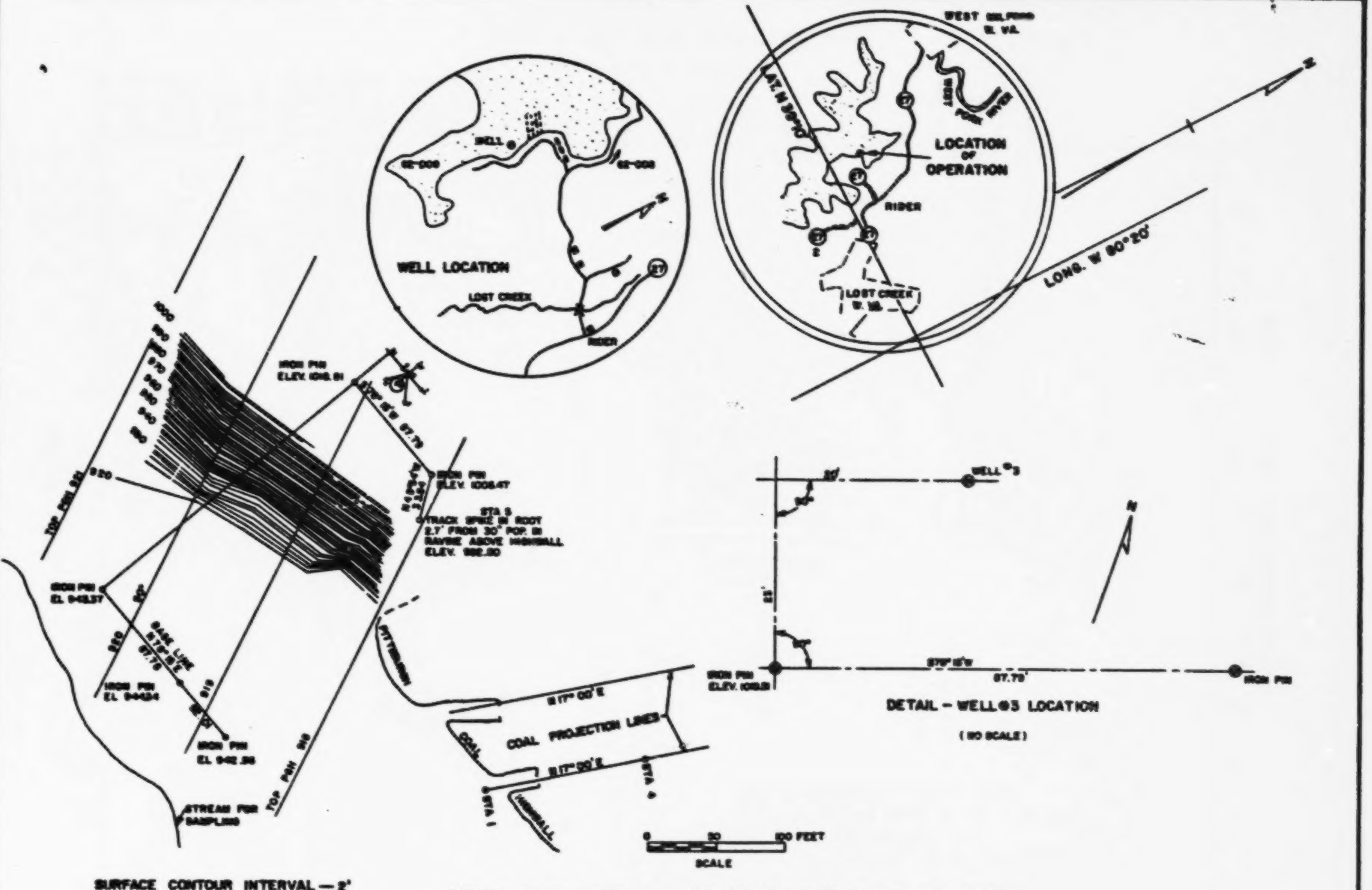
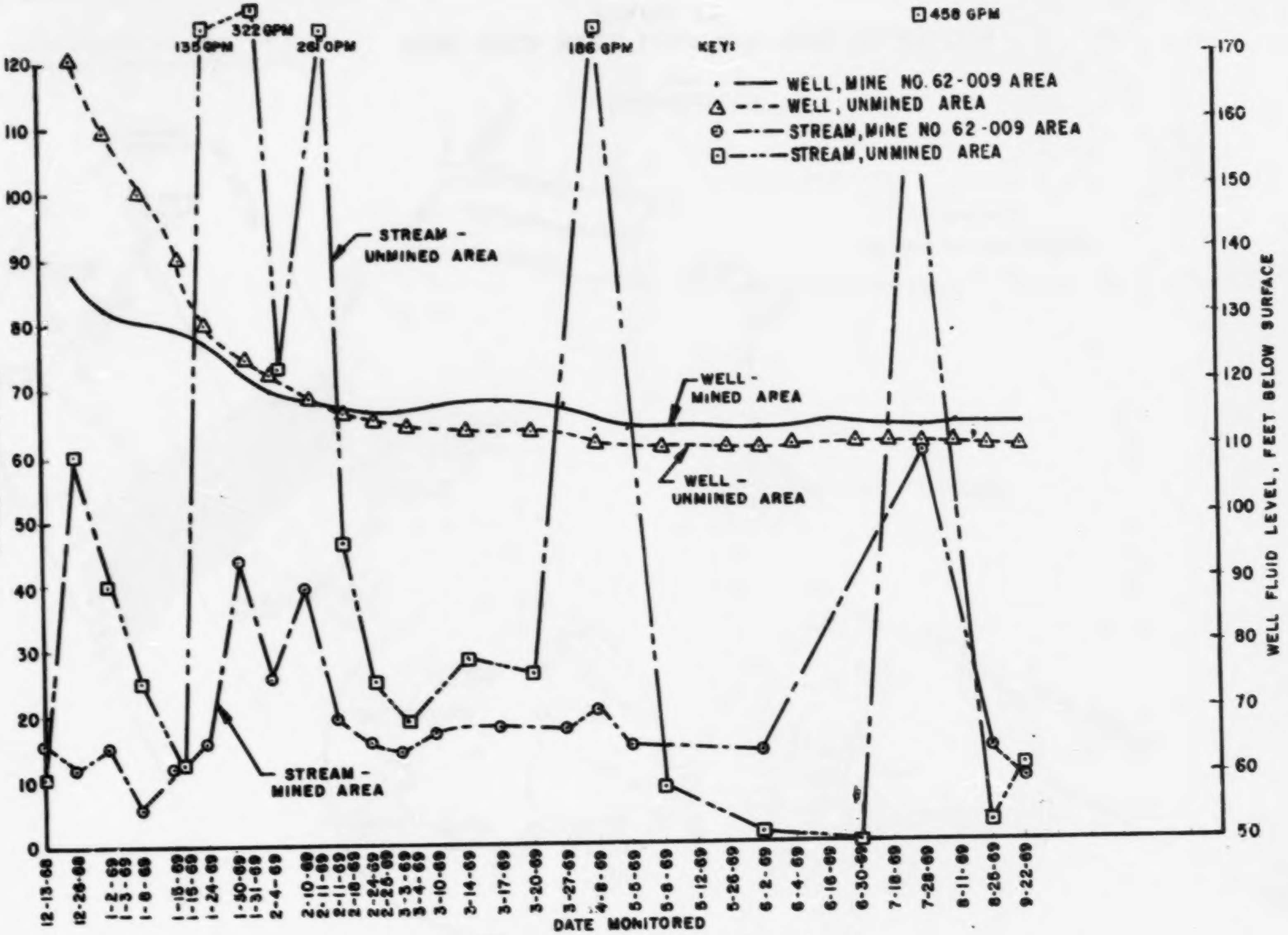


FIGURE 25 - DRILLING SITE TOPOGRAPHY - UNMINED AREA WELL


WEST MILFORD
W. VA.
WEST FORK RIVER
LOCATION
OF
OPERATION
RIDER
LOST CREEK
W. VA.
LAT. N 39°10'
LONG. W 80°20'
N
WELL LOCATION
WELL
62-009
62-009
LOST CREEK
RIDER
27
N
1000
990
980
970
960
950
940
930
920
TOP PNH 920
IRON PIN
ELEV. 1016.81
IRON PIN
ELEV. 1008.47
STA 3
TRACK SPIKE IN ROOT
2.7' FROM 30" POP. IN
RAVINE ABOVE HIGHWALL
ELEV. 992.30
IRON PIN
EL 943.37
BASE LINE
67.76
IRON PIN
EL 944.24
IRON PIN
EL 942.36
STREAM FOR
SAMPLING
TOP PNH 916
PITTSBURGH
COAL
COAL PROJECTION LINES
N 17° 00' E
N 17° 00' E
STA 1
STA 4
HIGHWALL
0
50
100 FEET
SCALE
WELL #3
IRON PIN
ELEV. 1018.0
67.70'
IRON PIN
N
DETAIL - WELL #3 LOCATION
(NO SCALE)
SURFACE CONTOUR INTERVAL — 2'
COAL CONTOUR INTERVAL — 1'

MINE AREA WELL LOCATION – MINE NO. 62-009
FIGURE 26



WATER LEVEL & STREAM FLOW DATA

FIGURE 27

The flow in the streams adjacent to the wells fluctuated over a wide range. The stream at Mine No. 62-009 stabilized at a flow of approximately 15 gpm on May 5 for the spring months. In the unmined area, flow varied widely and seemed to be more dependent on precipitation. The unmined area stream continued to decrease from a high of 322 gpm on February 4, to 1.8 gpm on June 2 and was not flowing on June 30, but flowed erratically for the balance of the monitoring period.

Also included in the Appendix is Table 15 which gives water analyses for well and stream from the mined area and Table 16 containing water analyses for well and stream from the unmined area. It was noted from this information that the water in the two wells was approximately the same pH and both were alkaline. The stream water showed a lower pH and contained more sulfate than the well water. The stream was generally harder than the well water.

Prior studies show that deep and surface mining operations affect the ground-water hydrology. It is reported (Ward and Wilmoth, 1968, p. 13) that deep mining in Marion County, West Virginia lowered ground-water levels to such a depth that some wells failed. After mining operations ceased, water levels in wells recovered to their approximate pre-mining level in 12 to 15 years. The greatest changes in and acceleration of ground-water drainage caused by coal mining usually takes place after the supporting coal pillars are removed. This permits the overlying rocks to settle and fracture, increasing the permeability and making it easier for water in the overlying rocks and on land surface to infiltrate into the mine (Herndon and Hodge, 1936, p. 8).

It should also be noted that Nace and Bieber (Bulletin No. 14, USGS, 1958, P. 10) state that measurements of the fluctuation of water levels in wells in Harrison County and surrounding counties, reveal a seasonal pattern of natural fluctuation. The water levels ordinarily are lowest in September or October, rise to their highest level in March or April, then decline to their lowest again in September or October. Precipitation during the summer months is mostly consumed by transpiration or evaporation and little or none percolates to ground-water reservoirs.

It can be seen that the water levels in the two wells seem to follow the pattern described by Nace and Bieber, although data have been gathered less than one year.

The well above the Redstone and Pittsburgh coals was cased off. The findings of this research dealt only with water tables from deeper sands below the Pittsburgh coal seam. These findings show much less fluctuation than would be expected for water tables above the coal seams which would be more affected by seasonal precipitation.

A mine opened in the Redstone coal would only drain ground water above the Redstone coal seam. A mine opened in the Pittsburgh coal would eventually drain any aquifers above the Pittsburgh seam.

By examining the geologic section of the area, it can be noted that a thick section of fire clay exists adjacent to the base of the Pittsburgh coal. This clay would not permit water above the Pittsburgh coal to percolate to lower aquifers, but there was an indication that some water does find its way to lower tables, since the water tables in the unmined area well stood 3 feet higher than that in a well of the mined area.

The primary difference in the water quality between the mined and unmined area was in the streams in each area. The stream in the mined area showed to have a higher acid, iron and sulfate content than the unmined area stream. The water in both wells was of similar quality and was almost neutral.

ACKNOWLEDGEMENTS

In the development and accomplishment of the studies and investigation requisite to the preparation of this report, the valuable assistance and suggestions of the Project Officers are gratefully acknowledged. During the Contract, four different Project Officers were assigned. They are listed below in chronological order:

Dr. Edward J. Martin - Washington, D.C.
July 15, 1968 to August 27, 1968

Mr. John R. Hyland - Wheeling, West Virginia
August 28, 1968 to March 16, 1969

Dr. Donald L. Warner - Cincinnati, Ohio
March 17, 1969 to September 17, 1969

Mr. Donald J. O'Bryan - Washington, D.C.
September 18, 1969 to end of Contract

In addition, the analyses of the many water samples by the Federal Water Pollution Control Administration Laboratory in Wheeling, West Virginia is deeply appreciated.

Mr. Paul W. Hornor, Consulting Mining Engineer of Clarksburg, West Virginia rendered valuable assistance in general consultation during the contract.

The cooperation of the personnel from the Federal Water Pollution Control Administration Laboratory at Norton, West Virginia is also gratefully acknowledged.

REFERENCES

Halliburton Company, "Selection and Recommendation of Twenty Mine Sites", Part II, 1967, Appendix, Table B.

Herndon, L.K., and Hodge, W. W., 1936, "West Virginia Coal Seams and Their Drainage": Proc. W. Va. Univ. Engr. Exper. Sta. Bulletin 14, 43 p.

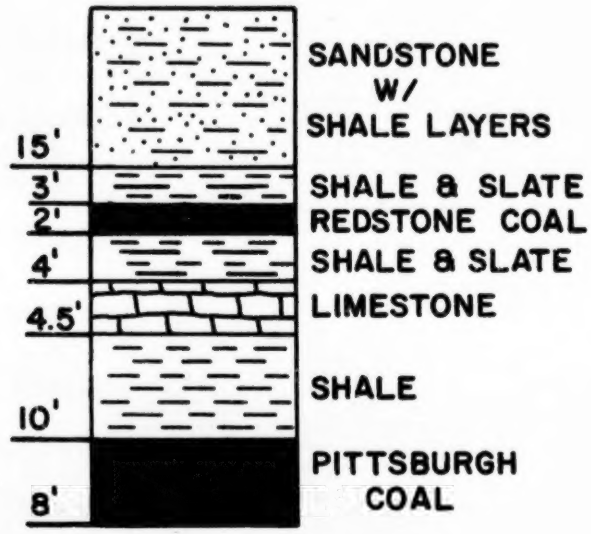
Nace, R. L. and Bieber, P. P., 1958, "Ground-Water Resources of Harrison County, W. Va.": W. Va. Geol. Survey Bulletin 14, 43 p.

Ware, P. E., and Wilmoth, B.M., 1968, "Ground-Water Hydrology of the Monongahela River Basin in West Virginia," W. Va. Geol. Survey River Basin Bul. 1, 54 p.

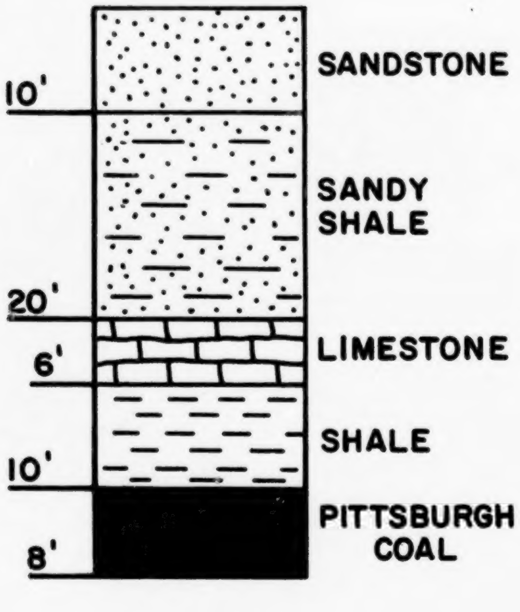
ABBREVIATIONS

alka.	alkalinity
AASHO	American Association of State Highway Officials
bpm	barrels per minute (1 barrel = 42 gallons)
cfs	cubic feet per second
cm	centimeters
disch.	discharge
ft	foot, feet
gpm	gallons per minute
hr	hour
hrs	hours
ID	inside diameter
in.	inch, inches
lbs/ft	pounds per foot
lbs/gal	pounds per gallon
lbs/min	pounds per minute
mq/l	milligrams per liter
ml	milliliters
No., #	number
OD	outside diameter
psi	pounds per square inch
scfm	standard cubic foot per minute
SP	Sample Point
USGS	United States Geological Survey

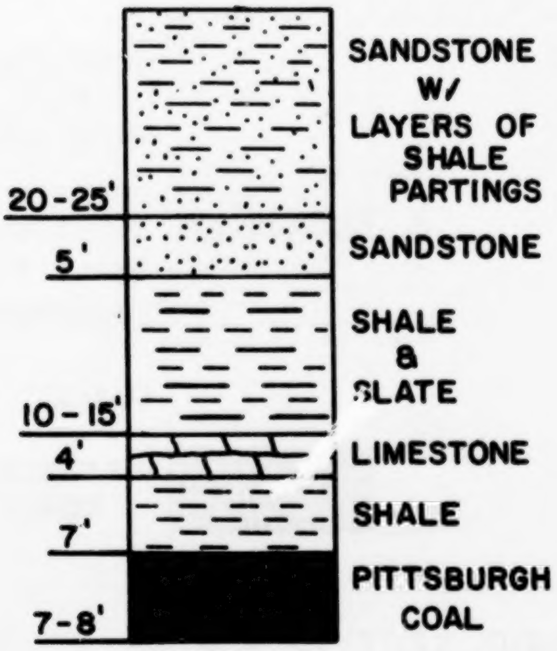
APPENDIX


SANDSTONE W/ SHALE LAYERS
15'
SHALE & SLATE
3'
REDSTONE COAL
2'
SHALE & SLATE
4'
LIMESTONE
4.5'
SHALE
10'
PITTSBURGH COAL
8'

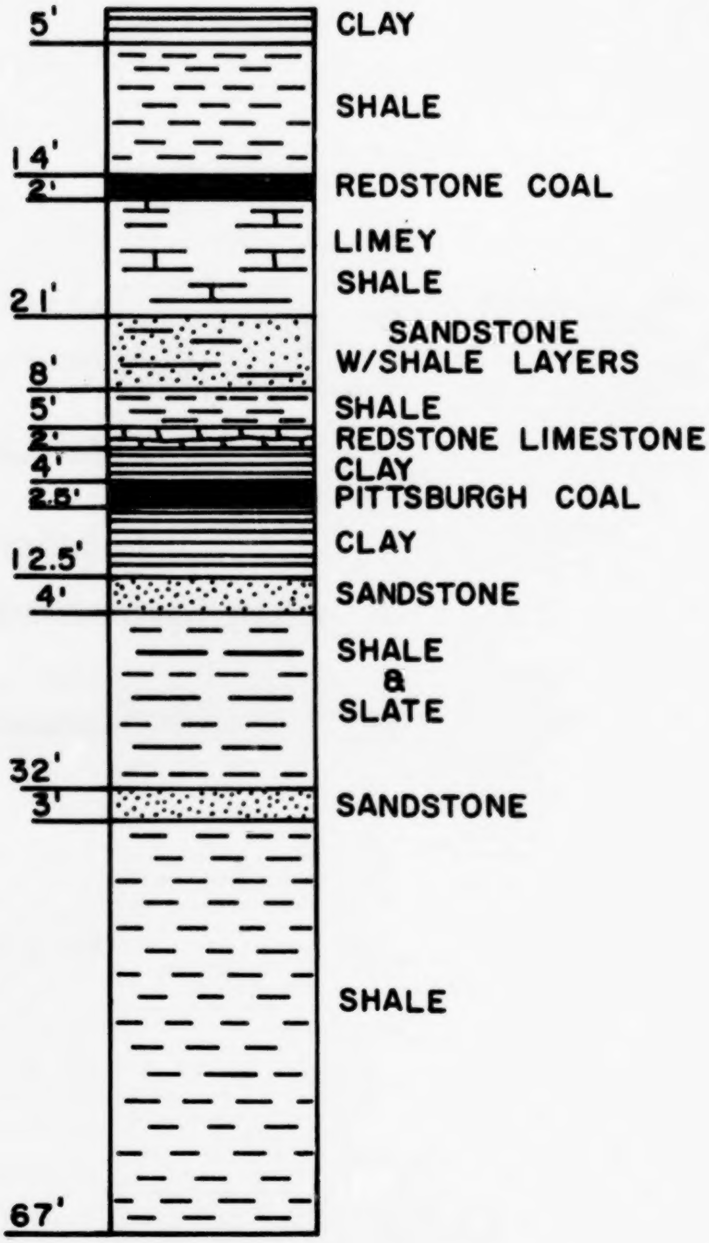
GEOLOGIC SECTION – MINE NO. 40-036
FIGURE 28


SANDSTONE
10'
SANDY SHALE
20'
LIMESTONE
6'
SHALE
10'
PITTSBURGH COAL
8'

GEOLOGIC SECTION – MINE NO. 40-064
FIGURE 29


SANDSTONE W/ LAYERS OF SHALE PARTINGS
20-25'
SANDSTONE
5'
SHALE & SLATE
10-15'
LIMESTONE
4'
SHALE
7'
PITTSBURGH COAL
7-8'

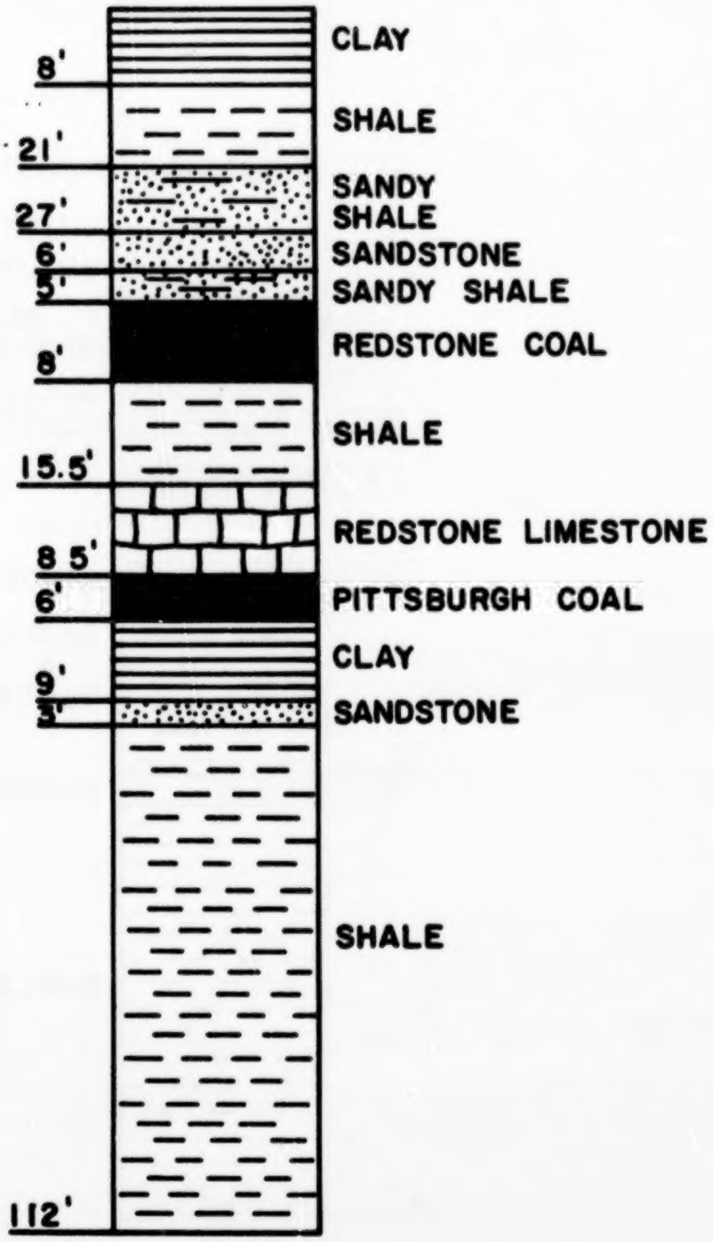
GEOLOGIC SECTION — MINE NO. 40-058
FIGURE 30


5'
CLAY
SHALE
14'
2'
REDSTONE COAL
LIMEY
SHALE
21'
SANDSTONE
W/SHALE LAYERS
8'
5'
SHALE
2'
REDSTONE LIMESTONE
4'
CLAY
2.5'
PITTSBURGH COAL
CLAY
12.5'
4'
SANDSTONE
SHALE
&
SLATE
32'
3'
SANDSTONE
SHALE
67'

GEOLOGIC SECTION

WATER WELL - UNMINED AREA

FIGURE 31


CLAY
8'
SHALE
21'
SANDY
SHALE
27'
SANDSTONE
6'
SANDY SHALE
5'
REDSTONE COAL
8'
SHALE
15.5'
REDSTONE LIMESTONE
8 5'
PITTSBURGH COAL
6'
CLAY
9'
SANDSTONE
3'
SHALE
112'

GEOLOGIC SECTION

WATER WELL - MINED AREA

FIGURE 32

TABLE 1

FLOW DATA OF MINES FROM PREVIOUS SURVEY

Mine No.	Date Sampled	Flow, gpm	Remarks
40-014	3- 2-67	No Opening	
40-034	11-18-65	1.6	
	1-10-67	1.3	
	2- 1-67	4.5	Opening No. 1
	2- 1-67	2.0	Opening No. 2
40-036	11-19-65	6.0	
	1-11-67	6.5	
	2- 1-67	7.5	
40-037	11-19-65	14.1	
	1-10-67	8.5	
	2- 1-67	8.0	
40-040	11-23-65	33.5	
	1-10-67	80.0	
	2- 1-67	72.0	
40-041	11-23-65	10.0	
	1-10-67	20.0	
	2- 1-67	24.0	
40-042	11-23-65	3.2	
	1-10-67	2.6	
	2- 1-67	2.0	
40-043	11-23-65	12.0	
	1-10-67	Seep	
	2- 1-67	15.0	
40-045	11-23-65	0	Dry
	1-11-67	0	
40-046	11-23-65	120.0	
	1-11-67	100.0	
40-051	11-24-65	0	Dry
	1-10-67	0	
40-052	11-29-65	2.5	
	1-10-67	0	
	3- 2-67	9.0	

TABLE 1 - Continued

FLOW DATA OF MINES FROM PREVIOUS SURVEY

Mine No.	Date Sampled	Flow, gpm	Remarks
40-053	11-29-65	5.5	
	3- 2-67	3.0	
40-054	11-29-65	0	
	1-10-67	2.5	
	1-30-67	0.5	
40-055	11-29-65	0	Dry
	1-10-67	0	
40-058	12- 1-65	1.5	
	1-11-67	Seep	
	3- 2-67	20.0	
40-063	12- 2-65	6.4	
	1-11-67	2.5	
	1-27-67	10.0	
40-064	12- 2-65	99.8	
	1-11-67	120.0	
	1-30-67	120.0	
40-065	12- 2-65	0	Dry
	1-11-67	0	
40-066	12- 2-65	87.2	Flow
	1-11-67	Seep	
40-067	12- 3-65	5.5	
	1-25-67	4.75	
	2- 1-67	4.0	Opening No. 1
	2- 1-67	1.5	Opening No. 2
40-070	12- 3-65	0	Dry
	1-12-67	0	
	3-12-67	0	
40-071	12- 3-65	0.5	Dry
	1-12-67	Seep	
40-073	12- 3-65	0	Dry
	1-12-67	0	

TABLE 1 - Concluded

FLOW DATA OF MINES FROM PREVIOUS SURVEY

Mine No.	Date Sampled	Flow, gpm	Remarks
40-074	12- 7-65	14.5	
	3- 2-67	0	Dry
	3-17-67	0	
40-079	12- 9-65	6.5	
	1-13-67	2.0	
	1-30-67	2.25	
40-081	12- 9-65	44.85	
	1-13-67	Seep	
	1-30-67	7.5	Opening No. 1
	1-30-67	24.0	Opening No. 2
	1-30-67	Seep	Opening No. 3
	1-30-67	6.0	Opening No. 4
40-083	12- 9-65	0	
	1-13-67	3.0	
	1-30-67	3.0	
40-085	12- 9-65	26.5	
	1-13-67	6.0	
	1-30-67	20.0	
40-087	12-10-65	0	Dry
	1-19-67	0	

TABLE 2

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 1*

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
9-20-68	-	3100	6.5	30	4	1110	5.0	1118	3.7
10- 3-68	1804	1574	5.0	245	0	805	28.4	936	17.5
10-17-68	774	2020	5.8	50	10	1090	2.6	1079	1.8
10-29-68	769	2016	5.6	35	9	1100	7.2	1170	4.2
11-11-68	930	1626	6.5	45	15	765	8.0	806	4.0
11-21-68	1747	1320	6.4	40	18	625	9.6	702	4.8
11-26-68	908	1680	6.0	50	16	820	12.0	832	7.6
12-12-68	1215	1560	6.0	110	16	520	11.0	806	5.0
12-18-68	1145	1820	6.2	30	24	965	12.0	930	4.8
12-30-68	-	984	6.2	0	7	550	12.0	468	2.9
1-20-69	2052	1080	6.6	44	19	535	7.5	585	<2.0
2- 3-69	3591	980	6.6	39	17	446	7.0	450	2.0
2-10-69	-	950	6.3	98	15	334	5.5	440	3.0
2-17-69	1912	1520	6.3	16	12	708	10.8	820	4.3
2-22-69	-	1626	6.5	142	4	804	11.7	948	5.4
3- 3-69	1243	1738	6.4	297	25	735	14.6	840	4.2
3-10-69	1305	1634	6.4	31	18	610	13.4	960	4.9
3-17-69	1060	1788	6.5	150	210	930	11.9	1020	<4.0
3-27-69	3019	1146	6.1	88	16	530	7.8	600	<5.0
4- 1-69	1583	1358	6.2	70	16	630	9.1	680	8.0
4- 7-69	3683	1026	6.1	52	22	420	6.2	480	<5.0
4-14-69	1574	1552	6.2	50	16	705	10.3	820	4.3
4-21-69	2118	1436	6.0	88	10	600	13.2	800	5.3
4-28-69	1835	1390	6.4	510	22	845	8.6	720	3.1
5- 5-69	1336	1700	6.2	76	14	950	7.2	900	3.5
5-12-69	3774	1042	6.7	25	23	435	6.9	380	5.5

* Mouth of Browns Creek.

TABLE 2 - CONCLUDED

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 1

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
5-19-69	1443	1588	6.0	11	15	895	9.2	920	6.0
5-26-69	811	1764	6.0	83	13	850	12.4	1005	4.6
6- 2-69	922	1922	6.7	37	21	475	8.7	1200	4.2
6-10-69	1006	1900	5.5	56	19	930	15.0	1180	3.5
6-16-69	1162	1568	5.5	68	16	725	10.7	900	4.8
6-23-69	939	1906	5.8	71	13	1060	10.2	1240	4.3
6-30-69	430	1968	7.1	0	72	1015	5.5	975	2.5
7- 7-69	618	1752	5.9	101	21	875	6.4	900	1.2
7-21-69	-	1205	6.5	17	17	565	6.3	570	1.2
7-29-69	-	766	7.2	24	27	717	6.4	700	4.0
8- 4-69	-	1606	6.4	104	25	865	8.3	900	3.0
8-12-69	1844	1220	6.6	181	24	530	6.8	690	2.5
8-18-69	688	1588	6.6	19	21	900	4.7	1000	1.4
8-25-69	524	1650	6.7	11	27	1095	2.8	1080	1.4
9- 2-69	540	1666	6.8	22	25	1055	-	1220	-
9-16-69	387	1742	7.0	111	25	1050	1.2	1100	0.3
9-22-69	607	1724	6.9	152	17	945	4.3	1060	4.7
9-30-69	495	1862	6.4	40	20	1010	4.3	1080	0.9

TABLE 3

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 2*

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
9-26-68	344	1972	4.7	110	0	640	11.7	1092	9.0
10- 3-68	1052	1560	4.7	90	0	900	24.6	930	10.6
10-17-68	389	2020	4.9	80	2	1050	6.2	1144	4.4
10-29-68	699	2026	5.0	125	3	1020	10.9	1118	5.2
11-11-68	645	1560	6.2	75	9	550	10.2	806	4.6
11-21-68	1314	1220	5.7	35	12	465	10.6	546	4.3
11-26-68	812	1620	5.9	60	7	780	20.4	884	9.6
12-12-68	935	1490	5.4	90	5	560	13.9	780	5.5
12-18-68	786	1740	6.0	35	13	850	16.3	923	6.3
12-30-68	-	880	6.4	20	12	550	8.8	442	4.0
1-20-69	1932	1000	6.2	52	13	500	8.4	525	<2.0
2- 3-69	3166	880	5.9	30	8	392	9.4	440	4.0
2-10-69	-	840	6.0	74	9	312	6.7	374	3.0
2-17-69	1489	1380	5.1	49	2	690	12.8	820	4.3
2-24-69	954	1590	5.2	170	4	782	14.1	920	6.7
3- 3-69	811	1706	5.9	320	11	655	17.9	1015	5.0
3-10-69	1011	1572	5.8	292	10	695	15.5	900	5.7
3-17-69	873	1740	6.2	171	16	870	14.8	930	4.5
3-27-69	2294	1052	6.2	80	14	515	9.4	450	<5.0
4- 1-69	1358	1270	6.0	63	10	600	9.9	660	7.5
4- 7-69	3392	926	6.2	56	15	402	6.6	440	<5.0
4-14-69	1140	1480	5.6	73	3	725	12.6	860	5.0
4-21-69	1834	1356	6.1	71	8	610	13.2	700	5.4
4-28-69	1577	1324	6.0	75	10	715	10.9	680	3.3
5- 5-69	1128	1646	4.8	112	3	870	10.8	940	4.4
5-12-69	2785	934	6.5	46	14	380	7.0	380	4.9

* One-half mile upstream from mouth.

TABLE 3 - CONCLUDED

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 2

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
5-19-69	1254	1540	4.9	53	3	795	19.0	900	6.0
5-26-69	730	1650	5.2	120	4	765	13.9	1005	5.2
6- 2-69	642	1942	6.1	78	7	840	12.1	1155	5.6
6-10-69	744	1882	5.6	125	10	840	18.4	880	5.7
6-16-69	1021	1522	5.0	95	9	740	11.8	940	5.0
6-23-69	725	1900	5.5	100	3	1055	14.2	1200	5.6
6-30-69	362	1802	6.9	70	62	1060	10.0	1040	3.2
7- 7-69	562	1738	6.1	98	12	980	11.0	930	2.0
7-21-69	-	1185	5.7	30	6	565	6.7	525	1.6
7-29-69	-	1296	6.9	56	16	705	8.7	765	4.3
8- 4-69	-	1614	5.4	138	5	815	10.2	920	4.2
8-12-69	1219	1141	5.9	156	7	490	7.8	615	3.4
8-18-69	357	1586	5.1	76	10	920	6.0	1000	2.4
8-25-69	380	1630	6.8	51	12	960	4.2	1000	3.0
9- 2-69	328	1742	6.3	32	12	1040	-	1200	-
9-16-69	363	1920	6.5	130	8	1075	3.5	1050	3.0
9-22-69	467	1740	5.9	157	10	955	6.8	1180	6.4
9-30-69	391	1862	5.9	61	7	930	9.8	1060	2.4

TABLE 4

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 3*

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
9-26-68	240	1934	7.0	315	58	945	8.8	910	5.5
10- 3-68	-	870	6.7	10	47	425	5.4	119	36.0
10-17-68	184	1976	6.6	0	66	1010	3.6	923	1.5
10-29-68	211	1966	6.7	35	49	1010	8.2	1066	4.3
11-11-68	524	1466	6.6	0	4	625	8.4	754	2.9
11-21-68	1220	1140	6.7	90	33	540	15.6	507	4.8
11-26-68	299	1532	6.5	50	42	700	10.8	754	3.3
12-12-68	479	1458	6.2	90	35	650	10.6	702	4.4
12-18-68	352	1620	6.4	75	49	750	13.6	819	3.7
12-30-68	-	842	6.7	0	26	480	5.7	379	2.3
1-20-69	1147	930	6.7	22	28	455	7.4	420	<2.0
2- 3-69	2802	800	6.6	18	21	352	5.9	360	2.0
2-10-69	-	740	6.4	80	20	262	5.1	324	2.0
2-17-69	1050	1310	6.3	18	24	618	10.7	700	3.6
2-24-69	812	1520	6.9	154	32	740	1.3	852	5.2
3- 3-69	540	1710	6.7	312	62	780	15.6	930	4.0
3-10-69	754	1506	6.6	236	42	730	12.8	855	5.0
3-17-69	686	1714	6.9	117	60	820	14.0	930	<4.0
3-27-69	1784	966	6.3	72	30	490	7.6	440	5.0
4- 1-69	1063	1180	6.5	32	30	580	8.1	615	6.0
4- 7-69	2375	848	6.4	40	29	364	5.3	420	<5.0
4-14-69	997	1416	6.4	39	34	715	16.2	765	3.8
4-21-69	1367	1270	7.2	30	33	595	3.7	645	2.4
4-28-69	1251	1242	6.7	28	40	790	8.1	615	2.6
5- 5-69	770	1580	6.4	41	33	770	8.4	870	3.5
5-12-69	2142	832	7.0	21	30	435	4.5	315	4.1

* Alpha Penn Road at Mount Clare.

TABLE 4 - CONCLUDED

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 3

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
5-19-69	808	1440	6.5	17	39	710	7.5	810	4.0
5-26-69	537	1660	6.7	70	48	875	11.8	1000	4.5
6- 2-69	427	1902	6.9	64	69	865	9.9	1180	5.0
6-10-69	560	1814	5.1	119	67	760	12.5	930	4.6
6-16-69	793	1490	6.0	50	49	740	2.5	630	5.1
6-23-69	417	1834	6.4	68	69	1015	10.4	1050	4.2
6-30-69	268	1908	7.3	66	150	975	7.2	750	2.3
7- 7-69	398	1754	6.7	54	80	875	9.0	920	1.5
7-21-69	-	1198	6.5	26	23	600	4.4	560	0.3
7-29-69	-	1240	7.1	70	52	665	6.1	630	3.1
8- 4-69	-	1652	7.2	185	72	665	5.2	885	1.4
8-12-69	469	1038	6.9	18	44	505	4.6	550	1.5
8-18-69	333	1574	6.7	0	65	930	4.0	880	1.0
8-25-69	360	1560	7.3	8	70	810	3.4	960	2.2
9- 2-69	310	1706	7.0	15	62	1050	-	1040	-
9-16-69	290	1900	7.3	50	72	1020	4.0	650	3.6
9-22-69	319	1702	7.2	110	56	935	5.6	1020	6.0
9-30-69	353	1822	7.1	85	60	1010	7.2	960	1.4

TABLE 5

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 4*

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
9-26-68	57	1636	3.7	5	0	660	2.6	832	22.3
10- 3-68	-	724	6.9	5	63	360	4.2	440	38.2
10-17-68	53	1838	3.4	280	0	815	4.7	943	23.0
10-29-68	395	1658	3.9	235	0	815	2.5	910	14.0
11-11-68	318	940	6.2	35	1	340	2.8	338	2.7
11-21-68	577	720	6.7	0	19	350	2.6	268	1.6
11-26-68	254	994	5.8	50	3	450	2.8	455	2.5
12-12-68	361	944	5.5	90	3	305	4.4	455	4.7
12-18-68	329	1090	5.1	50	1	480	5.1	559	5.9
12-30-68	-	560	6.6	0	16	390	2.2	247	1.6
1-20-69	668	600	6.4	22	15	289	2.5	375	<2.0
2- 3-69	1777	580	6.5	17	16	246	2.7	200	<2.0
2-10-69	-	540	6.3	27	12	198	2.8	205	2.0
2-17-69	589	900	5.7	45	2	420	4.9	460	2.8
2-24-69	425	1113	4.6	153	3	482	5.8	615	5.9
3- 3-69	307	1260	4.4	390	0	535	7.4	700	5.3
3-10-69	358	1104	4.6	300	3	445	6.9	610	4.8
3-17-69	316	1280	4.4	188	0	535	6.6	690	6.0
3-27-69	1355	672	6.4	65	12	315	3.5	270	5.0
4- 1-69	734	778	5.8	47	6	355	3.9	360	6.0
4- 7-69	1639	572	6.5	30	18	252	2.0	240	5.0
4-14-69	378	1012	4.7	100	0	520	3.9	490	5.5
4-21-69	710	-	-	81	4	344	4.5	410	5.1
4-28-69	554	850	5.6	81	62	495	3.4	410	3.5
5- 5-69	456	1328	3.6	196	0	525	8.8	670	8.3
5-12-69	1759	592	6.6	16	20	248	2.5	220	3.3

* Opposite Mount Clare Lions Club Park.

TABLE 5 - CONCLUDED

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 4

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
5-19-69	565	1098	4.4	60	0	575	3.2	580	7.5
5-26-69	222	1586	2.8	225	0	720	6.9	825	14.2
6- 2-69	66	2122	3.3	401	0	790	9.8	1400	22.2
6-10-69	94	1686	4.0	316	0	610	4.1	930	13.3
6-16-69	376	1168	4.8	105	1	540	7.8	855	4.2
6-23-69	70	1700	3.7	248	0	825	5.2	1098	15.2
6-30-69	28	2162	3.4	443	0	855	9.8	1150	24.4
7-21-69	-	950	4.4	64	0	515	2.3	430	2.6
7-29-69	-	828	7.1	37	14	465	2.3	190	3.6
8- 4-69	-	1322	4.2	355	0	485	1.8	660	10.9
8-12-69	272	690	6.9	38	24	390	1.3	310	1.7
8-18-69	103	1120	4.2	166	0	645	1.6	735	5.5
8-25-69	292	1210	4.3	186	0	605	1.6	690	9.8
9- 2-69	78	1608	3.6	289	0	795	2.3	1020	13.3
9-16-69	84	1622	3.7	268	0	860	2.0	840	17.1
9-22-69	50	1282	4.3	244	0	615	1.0	735	10.7
9-30-69	64	1364	4.4	154	0	645	-	-	-

TABLE 6

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 5*

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
10- 3-68	-	578	7.2	0	67	260	4.2	82	50.2
10-17-68	31	1180	6.6	0	91	605	0.7	494	0.4
10-29-68	42	1054	7.3	0	104	475	0.4	403	0.2
11-11-68	200	690	7.1	0	66	255	0.6	182	0.4
11-20-68	-	598	6.7	0	40	255	1.9	180	1.1
11-26-68	264	728	6.8	0	67	360	0.8	260	0.4
12-12-68	268	690	6.5	45	55	125	0.5	242	0.2
12-18-68	295	870	6.4	55	58	450	0.7	325	0.7
12-30-68	-	440	6.9	0	32	330	1.6	161	0.5
1-20-69	671	520	6.8	0	34	340	1.7	170	<2.0
2- 3-69	1717	510	6.8	5	26	226	3.0	170	2.0
2-10-69	-	450	6.7	22	23	196	2.6	170	2.0
2-17-69	188	740	6.5	0	29	370	3.5	360	1.1
2-24-69	197	964	6.4	139	30	478	3.4	494	1.8
3- 3-69	105	1013	6.5	234	46	470	3.2	480	2.5
3-10-69	-	860	6.5	149	39	455	3.6	390	3.1
3-17-69	85	960	6.8	75	47	555	1.4	440	<4.0
3-27-69	1039	542	7.1	20	35	293	2.1	210	<5.0
4- 1-69	520	616	6.9	2	38	288	1.3	220	<5.0
4- 7-69	1001	476	6.6	16	34	208	1.0	164	<5.0
4-14-69	135	794	6.8	3	36	364	0.9	310	1.7
4-21-69	255	-	-	0	39	320	2.0	265	2.0
4-28-69	167	670	6.7	6	45	565	10.4	270	0.7
5- 5-69	78	1034	4.7	61	2	605	5.9	510	2.4
5-12-69	1735	502	7.1	0	38	228	2.0	170	3.5
5-19-69	89	830	6.6	0	48	460	0.6	335	1.0

* Opposite Interstate Building.

TABLE 6 - CONCLUDED

FLUID FLOW DATA & WATER ANALYSES - BROWNS CREEK - SAMPLE POINT NO. 5

Date Sampled	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
5-26-69	56	1184	6.1	33	33	640	1.5	550	1.4
6- 2-69	57	1446	6.1	46	23	675	1.5	790	2.8
6-10-69	50	1182	5.7	45	72	545	1.4	530	0.4
6-16-69	90	934	6.3	41	71	390	1.0	410	2.7
6-23-69	12	1198	6.0	44	71	690	0.9	590	0.7
6-30-69	3	1284	6.1	39	110	715	0.9	540	0.8
7-21-69	-	830	6.2	11	21	430	1.9	340	0
7-29-69	-	614	7.5	0	69	305	0.7	230	0.9
8- 4-69	-	744	7.2	190	93	440	10.3	290	1.1
8-12-69	169	476	7.1	0	63	260	0.8	185	0.8
8-18-69	46	728	7.2	0	85	360	0.8	270	0.4
8-25-69	136	768	7.1	0	78	390	1.0	300	1.0
9- 2-69	39	872	7.2	0	87	485	0.9	360	0
9-16-69	19	924	7.3	82	91	610	0.5	400	2.0
9-22-69	49	1282	7.2	55	86	525	0.6	370	-
9-30-69	18	922	7.3	54	90	495	0.8	380	0.4

TABLE 7

POLLUTION DATA - BROWNS CREEK

Area Represented	Acid Produced[1] (lbs/mo)	Iron Produced[1] (lbs/mo)	Sulfate Produced[1] (lbs/mo)
Entire Browns Creek Watershed[2]	40,654	4,524	439,101
Two Lick Hollow and Hollow with Mine No. 40-040[3]	8,918	992	96,319
Conglomerate of mines on both sides of Browns Creek in Main Mount Clare Area[4]	10,339	1,264	94,049
Hutchison Hollow[5]	8,161	948	88,125
South Mount Clare Area, including Mine Nos. 40.053 and 40-063[6]	8,616	244	35,852
Area from Interstate Bldg. south to headwaters of Browns Creek, including Mine No. 40-058[7]	3,678	214	34,960

[1] Production of acid, iron and sulfate based on average of data from October, 1968 to October, 1969

[2] Data taken at discharge of Browns Creek into West Fork River.

[3] Difference in flow between SP No. 1 and SP No. 2. Analyses from SP No. 1.

[4] Difference in flow between SP No. 2 and SP No. 3. Analyses from SP No. 2.

[5] Difference in flow between SP No. 3 and SP No. 4. Analyses from SP No. 3.

[6] Difference in flow between SP No. 4 and SP No. 5. Analyses from SP No. 4.

[7] Flow in Browns Creek from headwaters to SP No. 5. Analyses from SP No. 5.

Note: SP No. 1 - SP No. 5 locations shown on Map, Figure 2.

TABLE 8

PHYSICAL CHARACTERISTICS
DRIFT MINE OPENINGS - DRAINING TO GROUND SURFACE

In the Browns Creek area the following abandoned drift mine openings include haulageways, fanways, drainways, etc., which discharge mine water directly to the ground surface. Other variations in condition or state of the mine openings are described under "Remarks".

Mine No.	No. of Openings	Remarks
40-014	7	Note B
40-056-1	1	Note B
40-070	1	Note B
40-079-1 & -2	2	Note A
40-079-3	1	Note B
40-081-1	1	Note A
40-081-2	1	Note B

Notes:

A - Drift opening partially closed by debris, sloughing material from proximity of opening, or by partial collapse of opening. Mine water often impounded behind the opening and flowing over and/or through the impounding material.

B - Mine opening at front completely filled by debris, roof collapse and subsidence or sloughing of material from the immediate area of the mine opening. In certain instances, mine openings have been closed or filled following abandonment or as part of the mine sealing program undertaken during the decade 1930-1940. Mine drainage flows from small crevices or channels in filling material or seeps through saturated fill material or percolates around the perimeter of the opening.

TABLE 9

DRIFT MINE OPENINGS - SUBSEQUENTLY STRIPPED
NO RECLAMATION

The following abandoned drift mine locations were stripped for the barrier coal and for underlying or overlying unmined coal beds, exposing haulageways, drifts, rooms, or crosscuts in a random manner and the strip has not been reclaimed in whole or in part. A similar condition is infrequently encountered where a coal seam has been drift mined subsequent to the coal strip operation and is included here though the degree of exposure of mined areas would be limited to that encountered and described in Table 8. In each case the mine opening at front has been completely filled by debris, roof collapse and subsidence or sloughing of material from the immediate area of the mine opening. In certain instances, mine openings have been closed or filled following abandonment or as part of the mine sealing program undertaken during the decade 1930-1940. Mine drainage flows from small crevices or channels in filling material or seeps through saturated fill material or percolates around the perimeter of the opening.

Mine No.	No. of Openings
40-051	1
40-064	2
40-066	2
40-084	2
40-086	1

TABLE 10

PHYSICAL CHARACTERISTICS
DRIFT MINE OPENINGS - STRIPPED AND BACKFILLED

This compilation includes abandoned drift mine locations which were stripped and the strip reclaimed by regrading the spoil to provide wide bench sloping or drainage toward the highwall. More recent strip reclamation projects where the strip bench is graded to slope away from the highwall are not found in the Sub-basin where mine drainage is in evidence or has been identified. Depending on the specific mine site, backfill may completely or partially cover the drift exposures. Other variations on these locations are noted in the "Remarks".

Mine No.	No. of Openings	Remarks
40-035-1 & -2	2	Note B
40-044	1	Note A
40-048	1	Note A
40-050	1	Note B
40-056-2	1	Note A
40-058	2	Note B

Notes:

A - Graded backfill has completely covered the coal bed exposure and mine drainage flows from the spoil, but the source of this drainage and the drifts are obliterated.

B - Location of opening is known either by observation or accurate mine maps.

TABLE 11

FLOW DATA & WATER ANALYSES - SELECTED MINES

Date Sampled	Location	Flow (gpm)	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
9-24-68	40-056-Opng.#2	1.63	2056	6.9	0	76	1370	5.6	1157	2.1
9-26-68	40-056-Opng.#1	6.00	2580	3.1	440	0	1120	10.4	1404	56.0
10- 2-68	40-050	3.40	2222	4.5	410	0	980	0.9	1118	2.6
10-14-68	40-048	1.00	1086	6.7	50	82	625	7.2	533	5.2
10-14-68	40-044	0.54	1682	2.9	520	0	395	67.2	780	27.8
10-15-68	40-035-Opng.#1	0.65	2342	7.1	58	239	970	0.8	1274	0.4
10-15-68	40-035-Opng.#2	1.67	2610	2.9	767	0	1075	9.0	1534	60.8
11- 5-68	40-066	6.75	2202	7.1	20	21	1410	21.6	1040	0.7
11- 6-68	40-081-1	9.00	3000	3.3	190	0	1775	38.4	1560	3.0
11-25-68	40-079-3	7.69	4020	2.8	1570	0	1390	540.0	2652	105.0

TABLE 12

DRILLER'S LOG - UNMINED AREA WELL

Depth (feet)	Formation	Remarks
0 to 5	Red Clay	
5 to 19	Gray Shale	First show of water
19 to 21	Redstone Coal	
21 to 32	Gray Shale	
32 to 33	Gray Lime	Water increasing.
33 to 42	Broken Lime & Shale	Water increasing.
42 to 46	Gray Sand	
46 to 50	Sand and Shale Streaks	
50 to 55	Gray Shale	
55 to 57	Gray Limestone	
57 to 61	Soapstone	
61 to 63.5	Pittsburgh Coal	
63.5 to 76	Soapstone	
76 to 80	Sandstone	
		Ran 6" casing to 80'. Shut off all water.
80 to 85	Limey Shale	
85 to 112	Slate	
112 to 115	Fine-grained, Hard Gray Sand	
115 to 116	Gray Shale	
116 to 118	Red Shale	
118 to 120	Dark Gray Shale	
120 to 125	Gray Shale	
125 to 162	Streaks of Red and Gray Shale	
162 to 165	Red and Gray Shale	
165 to 170	Gray Shale	
170 to 175	Red Shale	
175 to 180	Red Shale	
180 to 182	Red Shale	
182		Total Depth - No shows of water.

TABLE 13

DRILLER'S LOG - MINED AREA WELL

Depth - (feet)	Formation	Remarks
68.5 to 76.5	Redstone Coal	)
76.5 to 76.8	Gray Shale	) Core #1 - Feb. 8, 1968
76.8 to 77.5	Coal	)
77.5 to 80.5	Gray Shale	)
80.5 to 81.9	Shale	)
81.9 to 90.5	Redstone Limestone	) Core #2 - Feb. 8, 1968
97.0 to 103.0	Pittsburgh Coal	
103.0 to 112.0	Fire Clay	
112.0 to 115.0	Sandstone	
115.0 to 120.0	Gray Shale	
120.0 to 130.0	Red Shale	
130.0 to 135.0	Gray Shale	
135.0 to 160.0	Red Shale	
160.0 to 170.0	Gray Shale	
170.0 to 183.0	Red Shale	
183.0 to 200.0	Streak of Red and Gray Shale	
200.0 to 205.0	Gray Shale	
205.0 to 227.0	Streaks of Red and Gray Shale	

TABLE 14

MONITORING DATA
WATER WELLS AND ADJACENT STREAMS

Date	Well Fluid Level, Feet		Stream Flow, gpm	
	Mine 62-009	Unmined Area	Mine 62-009	Unmined Area
12-13-68	-	-	15.6	10.5
12-26-68	137.6	171.0	12.0	60.0
1- 2-69	132.1	-	15.0	-
1- 3-69	-	159.6	-	40.0
1- 8-69	130.6	150.4	5.6	25.0
1-15-69	129.7	-	12.0	-
1-16-69	-	140.1	-	12.0
1-24-69	127.1	130.7	15.5	135.0
1-30-69	123.2	-	43.3	-
1-31-69	-	124.9	-	322.0
2- 4-69	119.7	122.3	25.6	73.0
2-10-69	118.4	-	39.1	-
2-11-69	-	118.9	-	261.0
2-17-69	117.2	-	19.2	-
2-18-69	-	116.1	-	46.1
2-24-69	116.7	-	15.8	-
2-25-69	-	115.1	-	25.0
3- 3-69	116.7	-	14.3	-
3- 4-69	-	114.1	-	18.7
3-10-69	117.7	-	17.1	-
3-14-69	-	113.6	-	28.6
3-17-69	117.7	-	18.1	-
3-20-69	-	113.5	-	26.1
3-27-69	118.0	-	17.7	-
4- 8-69	113.9	111.6	20.7	186.0
5- 5-69	113.4	-	15.0	-
5- 8-69	-	110.9	-	8.9
5-12-69	114.1	-	-	-
5-26-69	-	110.8	-	-
6- 2-69	113.4	111.0	14.6	1.8
6- 4-69	-	111.5	-	-
6-16-69	114.5	-	-	-
6-30-69	-	111.4	-	0
7- 7-69	114.1	-	-	-
7-18-69	113.9	111.4	-	-
7-28-69	113.6	111.2	62.2	458.0
8-11-69	114.9	111.1	-	-
8-25-69	114.2	110.9	14.2	3.0
9-16-69	114.3	-	-	-
9-22-69	114.3	111.0	9.8	11.8
9-29-69	-	111.0[1]	-	-
10- 6-69	113.6	-	13.3	-

[1] Removed Water-Level Recorder from well.

TABLE 15

WATER ANALYSES - MINED AREA

Date Sampled	Location	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
11-21-68	Well[1]	2814	5.5	440	6	1500	146.4	1846	0
12- 2-68	Well[2]	2510	7.9	0	552	300	39.0	33	12.7
12- 3-68	Well[3]	2720	8.2	0	4940	40	8.4	10	3.3
12-13-68	Stream	2500	5.2	90	41	1150	10.8	364	15.8
12-26-68	Well	1540	8.3	0	487	150	3.0	8	2.0
12-26-68	Stream	2500	5.8	50	18	1460	19.2	1352	5.6
1- 2-69	Well	1600	7.9	0	587	100	7.8	10	0
1- 2-69	Stream	2800	5.9	40	23	1700	19.2	1612	1.6
1- 8-69	Well	1630	7.8	0	569	70	2.6	17	0.5
1- 8-69	Stream	2900	6.0	25	21	1530	15.7	1820	4.1
1-15-69	Well	1520	7.2	70	561	35	0.8	5	0
1-15-69	Stream	2640	6.2	110	46	1490	12.8	1677	3
1-24-69	Well	1540	8.3	0	573	40	2.2	5	< 2.0
1-24-69	Stream	2050	5.6	275	5	1710	13.1	1375	3.6
1-30-69	Well	1560	8.3	0	561	20	3.0	6	4.5
1-30-69	Stream	1850	5.3	90	3	980	14.4	1075	9.2
2- 4-69	Well	1380	8.2	0	561	40	9.3	11	3.0
2- 4-69	Stream	2260	6.7	50	28	1920	9.3	1350	< 2.0
2-10-69	Well	1560	8.2	0	569	20	5.4	12	2.0
2-10-69	Stream	2090	6.1	200	15	935	12.4	1400	3.0
2-17-69	Well	1520	8.0	0	554	18	4.9	17	0.9
2-17-69	Stream	2760	7.2	4	40	1354	11.0	1750	2.2

[1] Sample taken from well at Mine No. 62-009 while drilling. Depth - 103 feet.

[2] Sample taken from well at Mine No. 62-009 while drilling. Depth - 183 feet.

[3] Sample taken from well at Mine No. 62-009 while drilling. Depth - 211 feet.

TABLE 15 - Concluded

WATER ANALYSES - MINED AREA

Date Sampled	Location	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
2-24-69	Well	1560	8.2	0	61	25	2.4	17	1.8
2-24-69	Stream	2904	6.7	63	51	1270	10.0	2275	2.4
3- 3-69	Well	1566	8.5	0	664	20	1.9	6	2.0
3- 3-69	Stream	3060	7.0	390	55	1230	11.0	1701	2.0
3-10-69	Well	1426	8.1	0	576	815	2.1	9	<2.0
3-10-69	Stream	2972	6.7	279	49	1185	11.8	2100	3.0
3-17-69	Well	1500	9.0	0	566	6	1.9	10	<4.0
3-17-69	Stream	3098	7.5	118	52	1555	10.0	2135	<4.0
3-27-69	Well	1520	8.2	20	537	23	5.5	30	<5.0
3-27-69	Stream	2900	6.7	70	24	1335	14.5	1645	<5.0
4- 8-69	Well	1540	8.2	0	567	23	1.0	20	<5.0
4- 8-69	Stream	2592	7.1	48	57	1340	5.3	1110	<5.0
5- 5-69	Well	1540	8.1	0	594	45	4.5	30	1.0
5- 5-69	Stream	2960	6.8	0	54	1290	2.3	1925	1.1
6- 2-69	Well	1560	7.9	0	568	10	1.2	35	1.0
6- 2-69	Stream	3200	7.1	32	53	1140	2.5	2065	1.3
6-30-69	Well	1570	7.9	0	634	23	2.6	960	0
6-30-69	Stream	3310	7.4	0	94	1284	1.0	1680	0
7-28-69	Well	1430	7.7	0	506	120	3.4	840	0.8
7-28-69	Stream	1732	5.7	106	35	815	21.4	920	5.1
8-25-69	Well	1420	6.7	0	556	16	2.1	30	0
8-25-69	Stream	2742	6.6	3	63	1920	1.7	1820	1.6
9-22-69	Well	1422	8.1	0	580	16	2.4	25	0.3
9-22-69	Stream	2922	7.7	71	65	1455	1.8	1925	0.2

TABLE 16

WATER ANALYSES - UNMINED AREA

Date Sampled	Location	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/l)	Alka. as $CaCO_3$ (mg/l)	Hardness as $CaCO_3$ (mg/l)	Iron (mg/l)	Sulfate (mg/l)	Aluminum (mg/l)
12-10-68	Well[1]	444	6.4	50	210	140	72.0	21	34.1
12-12-68	Well[2]	620	7.2	20	284	40	51.6	38	9.5
12-13-68	Stream	144	6.1	15	24	50	0.6	179	0
12-26-68	Well	2100	8.8	0	667	330	9.6	23	2.0
12-26-68	Stream	152	8.0	20	28	120	0.2	10	0.1
1- 3-69	Well	2052	8.1	0	650	90	13.4	43	9.5
1- 3-69	Stream	116	7.0	90	25	230	0.5	9	0
1- 8-69	Well	2134	8.5	0	645	10	7.4	39	5.9
1- 8-69	Stream	130	6.6	0	22	70	0.4	13	0.2
1-16-69	Well	2220	8.3	0	640	25	8.4	31	5.2
1-16-69	Stream	184	4.6	170	2	50	0.8	15	0
1-24-69	Well	1850	8.7	0	630	120	31.0	34	89.5
1-24-69	Stream	90	6.9	10	21	40	0.8	10	< 2.0
1-31-69	Well	2000	8.7	0	620	10	9.7	39	12.5
1-31-69	Stream	965	6.8	40	18	48	0.4	11	2.0
2- 4-69	Well	2020	8.9	0	648	45	7.7	40	12.3
2- 4-69	Stream	98	6.7	22	20	55	0.5	13	0
2-11-69	Well	1960	8.8	0	609	40	31.7	30	72.8
2-11-69	Stream	112	7.1	71	19	40	0.4	10	< 2.0
2-18-69	Well	1920	8.8	0	630	10	30.0	35	58.0
2-18-69	Stream	110	7.4	5	20	44	0.4	10	0.9
2-25-69	Well	1994	8.8	0	622	9	37.0	35	170.0
2-25-69	Stream	134	6.9	226	24	60	0.3	10	1.4

[1] Sample taken from well while drilling. Depth - 30 feet

[2] Sample taken from well while drilling. Depth - 79 feet

TABLE 16 - Concluded

WATER ANALYSES - UNMINED AREA

Date Sampled	Location	Cond. (umhos/cm)	pH	Acidity as $CaCO_3$ (mg/1)	Alka. as $CaCO_3$ (mg/1)	Hardness as $CaCO_3$ (mg/1)	Iron (mg/1)	Sulfate (mg/1)	Aluminum (mg/1)
3- 4-69	Well	1920	8.7	0	601	22	29.1	-	36.0
3- 4-69	Stream	105	7.0	98	27	60	0.3	6	< 2.0
4- 8-69	Well	131	7.0	50	27	52	0	50	< 5.0
4- 8-69	Stream	2360	7.0	0	305	98	0.6	20	< 5.0
5- 8-69	Well	2100	-	0	560	60	0.4	52	1.2
5- 8-69	Stream	146	7.3	9	38	56	0.1	35	1.0
6- 2-69	Well	2050	6.9	0	548	31	0.4	60	1.1
6- 2-69	Stream	167	7.1	2	40	45	0.7	50	1.4
6-30-69	Well	1762	7.6	0	660	50	0.5	60	0
7-28-69	Well	1788	7.3	0	550	46	2.0	140	0
7-28-69	Stream	151	7.0	9	30	49	0.9	235	0.3
8-25-69	Well	1784	4.7	0	544	48	0.6	60	1.6
8-25-69	Stream	-	-	-	-	-	-	-	-
9-22-69	Well	1764	7.6	0	464	71	0.1	55	0.4
9-22-69	Stream	116	7.5	43	41	58	0.2	20	1.0

BIBLIOGRAPHIC: Halliburton Company, "Investigative
Mine Survey of a Small Watershed"
FWPCA Program No. 14010 DMO

ABSTRACT: The primary purpose of this project was to conduct an investigation to locate hidden or unknown drift mine openings in the Browns Creek Watershed in Harrison County, West Virginia. Thirty unknown openings were discovered in an initial reconnaissance. Additional probing using power driven augers was not successful and was deemed impractical. Three specific areas within the watershed were selected for further scrutiny. The bottom of the highwall line in the strip mined area was determined by land surveyors and this information was plotted on old mine maps to indicate the intersection of the stripping with underground mining. A minimum of 107 mine drifts were shown to be exposed by the 14,500 feet of highwall surveyed in the three areas. This report was submitted in partial fulfillment of Contract No. 14-12-453 between the Federal Water Pollution Control Administration and the Halliburton Company.

KEY WORDS:

Mine Surveys

Powered Auger Probing

Hidden Mine Openings

Highwall Locations

Strip Mining Effects

Exposed Drifts

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